

EQUITY

RESEARCH:

JAPAN

## Equity Strategy

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# The Global Environment and Socially Responsible Investment

## Environmental Technologies Fueling Zones of Growth

- **Global warming is a grave problem, and the heat island effect in Japanese cities is becoming increasingly serious**
- **Interest in the environment is growing, but it is no easy matter to manage the trade-off between environmental problems and economic growth**
- **Needs for technologies and products to solve environmental problems are growing and are creating a major environmental market**
- **For instance, because of the need to solve environmental problems, the shift from gasoline-powered cars to fuel-cell cars is occurring, and natural gas is in the spotlight as an energy source for the electric power industry**
- **Toyota Motor is at the global cutting-edge when it comes to low-emission vehicle (LEV) technologies, and we think it stands to benefit more than any other Japanese company**
- **Tokyo Gas, Honda Motor, and Mitsubishi Corp. also have an advantage in this area, in our opinion**
- **We explore environmental activities in the chemicals, consumer electronics, and pharmaceuticals sectors, spotlighting work by Mitsubishi Gas Chemical (MGC), Ube Industries, Matsushita Electric Industrial (MEI), Sharp, Sanyo Electric, Terumo, and others**

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## Investment thesis

### **Managing the trade-off between protecting the environment and expanding energy supplies**

It is not easy to expand energy supplies and protect the environment simultaneously, but we believe power technology can help resolve this dilemma. We expect the need to strike a balance between energy supply and environmental protection to have a major impact on the activities of global corporations and industries for years to come.

### **Awareness of environmental issues growing**

Problems surrounding the ratification of the Kyoto Protocol have raised awareness of environmental problems and of the challenge of reconciling the competing demands of the environment and the economy. Power technology is helping to make them compatible. The shift from gasoline-powered vehicles to those that run on fuel cells and the attention given to natural gas and nuclear energy as electric power sources are both consequences of the need to solve environmental problems. This helps to create new markets, generate profits for corporations, and create growth stocks.

### **What do we mean by power technology?**

We define the term power technology to encompass such fields as oil, gas, environmental technology, power resource development, and alternative energy, just as the term information technology (IT) includes such fields as electric machinery, precision equipment, telecommunications, and the Internet.

### **Power technology and stock investments**

Power technology is above all a long-term investment area—we do not expect power technology-related shares to climb sharply in the near-term. We think investment targets will change over time as power technologies evolve. We see near-term merit in investments in companies involved in oil and LNG plant supply, because of greater oil and natural gas use, and gas-turbine-related companies, as US electricity shortages stimulate increased demand for new power stations. In the medium term, we recommend companies involved in hybrid vehicle development and in distributed power generation, and over the long term, we think nuclear power generation and fuel-cell vehicles are areas worth watching.

### **Chemicals**

In response to problems with pollution, efforts by chemical manufacturers to clean up their gas emissions and wastewater and otherwise lighten the burden on the environment are showing results. Changes in social consciousness about environmental problems, and legal system amendments present new business opportunities as evidenced by Mitsubishi Gas Chemical's (MGC's) DME (dimethyl ether) business and Ube Industries' move into the environmental field. Development of biodegradable plastic is progressing, and the market is gradually expanding.

### **Consumer electronics**

Our vision for longer-term growth in the consumer electronics industry focuses on establishing and sustaining decisive superiorities in digital audiovisual technologies and environmental technologies as core technologies. The sector's first environmental moves have been in line with energy conservation and home appliance laws. The second steps have been based on each firm's technological prowess, specifically the production of products that conserve energy and that meet environmentally responsible guidelines, while

establishing environmentally conscious manufacturing infrastructure. The third moves have been focused on new energies with lower CO2 emissions, such as rechargeable batteries for electric vehicles, home solar power systems, and residential-use fuel-cell cogeneration.

### **Pharmaceuticals**

The Japanese pharmaceutical industry is working to address environmental issues, mainly through the Japanese Pharmaceutical Manufacturers Association (JPMA), which has 80 member companies. The JPMA has published an annual environmental report since 1999, and 57% of members companies had published individual reports as of FY3/03. However, these reports did not address such issues as unknown harmful substances, animal welfare, and medical malpractice, and we think the industry needs to make improvements in these areas.

## Environment Issues Take Center Stage

- **Global environmental issues demand solutions at the international level due to their global scale and the need to ensure the sustainable development of mankind in harmony with the environment**
- **General awareness of environmental issues has risen in Japan amid difficulties with ratification of the Kyoto Protocol and the emergence of the heat island phenomenon in major Japanese cities**
- **The term power technology refers to energy-related technologies that offer solutions to environmental issues by making economic growth compatible with environmental protection. In effect, power technology is a source of added value created by tackling environmental issues**
- **The overall environment/energy market in Japan is projected to grow to ¥55trn by around 2010 from ¥22trn currently, according to the Ministry of Economy, Trade and Industry (METI) Council on Industrial Structure Committee on New Growth Industries**

*Environmental issues demand international cooperation to solve*

### Global environmental issues

Global environmental issues are worldwide in scale by virtue of the fact that the impact of the pollution or destruction caused by any single country or region cannot be contained. Such environmental problems are ones that demand solutions based on international cooperative efforts spanning both developed and developing nations.

We look briefly at these issues under the following nine headings: 1) global warming, 2) ozone layer depletion, 3) acid rain, 4) species loss, 5) deforestation and rain forest destruction, 6) desertification, 7) marine pollution, 8) cross-border movement of hazardous wastes, and 9) environmental issues in developing countries. Mankind's continued existence is gradually approaching limits from the twin perspectives of environmental capacity and resource cycles, to the point where many are demanding fundamental change to promote a shift toward a society that coexists with the environment based on sustainable development. Moreover, as single individuals, companies, or countries cannot solve these environmental issues on their own, the onus needs to be on cooperation between nations on a global scale.

#### 1. Global warming

Global warming refers to a rise in average global temperatures due to the heat-trapping effects of increasing volumes of atmospheric greenhouse gases (GHGs), such as CO<sub>2</sub>. GHG concentrations have risen sharply since the industrial revolution. Recently, this observation has generated widespread concern that human socioeconomic activities may be resulting in global warming. Global warming is predicted to have a number of major effects, outlined below.

- Significant coastal erosion due to a general rise in sea levels
- More abnormal weather conditions, such as monsoons and droughts
- Adverse effects on ecosystems, such as increased desertification
- Adverse effects on agricultural production and marine resources
- Increased incidence of tropical diseases, such as malaria

There have been a number of international initiatives to prevent global warming, notably the adoption of the United Nations Framework Convention on Climate Change (1992: UNFCCC).

## **2. Ozone layer depletion**

Ozone layer depletion refers to the destruction of ozone within the Earth's stratosphere due to reactions caused by such manmade chemicals as chlorofluorocarbons (CFCs), which tend to linger and accumulate in the upper atmosphere. Stratospheric ozone plays a critical role in absorbing most of the ultraviolet radiation from the sun that is harmful to living creatures. Destruction of the ozone layer could therefore have a potentially devastating effect on a vast array of life on Earth, including mankind, as it would expose the planet's surface to increased ultraviolet irradiation. Besides detrimental effects on human health, such as an increased incidence of skin cancer, cataracts, and immunosuppressive disorders, it could also cause major atmospheric pollution, leading to growth retardation among many animals and plants and other adverse effects on ecosystems.

The international community has tackled the threat of ozone depletion through the adoption of accords such as the Vienna Convention on the Protection of the Ozone Layer (1985) and the Montreal Protocol on Ozone-Depleting Substances (1987). These agreements establish rules that limit the production of ozone-depleting substances, with specific phase-out schedules for different substances. Japan has enacted its own legislation to help protect the ozone layer by means of regulations governing specific chemical substances, based on international accords.

## **3. Acid rain**

Acid rain is a phenomenon caused by the conversion in the atmosphere of oxides of sulfur (SO<sub>x</sub>) and nitrogen (NO<sub>x</sub>) produced by the combustion of fossil fuels into acidic chemical compounds that are then deposited back on the Earth's surface after dissolving in rainwater. Besides being a serious internal problem for many countries in terms of atmospheric pollution, acid rain is also an international issue because the sulfur and nitrogen oxides that cause it are emitted as exhaust gases. Such substances can be transported thousands of kilometers in the atmosphere before harming an entirely different area. Acid rain is thus a major environmental issue the solution of which necessitates international cooperation.

The acknowledged impact of acid rain includes adverse effects on ecosystems, such as forest decay and the acidification of rivers, lakes and marshes, as well as harm caused to historic buildings and cultural sites. Damage caused by acid rain has been widely reported, notably in Europe, North America, and other regions with developed manufacturing bases, and also in China.

Collaborative international efforts to tackle the problem have been led by Europe, where the damage has been greatest. Various treaties and agreements have been reached, including the Convention on Long-Range Transboundary Air Pollution (1979), the Helsinki Protocol (1985), and the Sofia Protocol (1988). Progress has also been made in the form of public emission control regulations designed to curb SO<sub>x</sub> and NO<sub>x</sub> emissions.

## **4. Species loss**

Species loss is the result of the ongoing extinction of many wild animal and plant species. Concerns abound that the rate of extinction is rising specifically as a result of human activities. While the direct culprits are indiscriminate hunting and poaching, destruction and elimination of ecosystems as a result of rain forest clearance, marine pollution, and desertification also play an increasing role. More general environmental degradation wrought by such factors as global warming and acid rain also contributes to the problem. The ongoing fall in numbers of wildlife species is believed to be shrinking the global gene pool while having an adverse impact on resources for tourism and recreation. If biodiversity losses continue to mount, there is even a possibility that the continued existence of humans will be threatened as the intricate mesh of interrelationships between different species starts to disintegrate.

International attempts to conserve wildlife and preserve biodiversity have included a number of agreements, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973: CITES, also known as the Washington Convention), the Convention on Wetlands of International Importance (1971: the Ramsar Convention), and the Convention on Biological Diversity (1992). These efforts all aim to halt the process of species loss.

### **5. Deforestation and rain forest destruction**

Loss of rain forest and general deforestation have become regionally severe problems in recent years—for instance, in Russia and northern Canada, where the conifer forests are disappearing. Rainforest destruction is directly attributable to a variety of practices, such as slash-and-burn agriculture, forest clearance to create pastoral and agricultural land, excessive gathering of firewood for fuel, and illegal commercial logging. Any solution is made unusually difficult by a complex mix of underlying socioeconomic factors, which include rapid population growth, industrialization, poverty, and land regulation. Excessive logging is the main cause of conifer deforestation in northern latitudes. Deforestation not only leads to the extinction of species and the destruction of ecosystems, but is also believed to contribute to global warming.

Although there are no international agreements in this area, several international bodies are undertaking various projects aimed at conserving forests. These organizations include the United Nations Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP), and the International Tropical Timber Organization (ITTO).

### **6. Desertification**

Desertification is a progressive problem associated with increasing levels of aridity, which are caused by a decline in precipitation related to climate change (note that the term does not refer to the encroachment of existing deserts). It now affects a number of developing countries, the main underlying causes being: 1) over-cultivation caused by population growth; 2) clearing of trees to create grazing land and collect firewood; and 3) a loss of land fertility as the interval between periods when the land is left fallow is shortened. Deserts are now believed to have swallowed up as much as 70% of the arable land in the world's arid regions, and now cover approximately 25% of the entire global land area.

Desertification generates its own problems, such as 1) the deterioration of a country's food production base; 2) the loss of biodiversity; 3) the acceleration of poverty; 4) the promotion of further climate change; 5) an increased urban population concentration; and 6) an increase in numbers of refugees. These outcomes in turn tend to promote other environmental problems, including further desertification, producing a vicious cycle of woe.

The UN has adopted its own program to highlight and tackle the problems of desertification. International efforts revolve around the UN Convention to Combat Desertification (1994).

### **7. Marine pollution**

Pollution of the seas and oceans is on the rise and is attributable to a variety of factors caused by human activities. These include 1) tanker accidents, 2) dumping of wastes at sea, 3) the influx of pollutants that have accumulated in rivers, and 4) coastal development. Marine pollution is widely acknowledged as a major environmental problem of global proportions because it is not easy to clean up and its effects impinge on many countries and their regional environs. As marine pollution becomes progressively more severe, it poses a number of threats ranging from ecosystem destruction and the loss of fisheries, marine resources, and tourist spots to more insidious effects on human health as toxic pollutants gradually accumulate in the marine food chain.

International efforts to combat the problem include such legal treaties as the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) and the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972: the London Convention), as well as adopted sets of rules such as the United Nations Convention on the Law of the Sea (1982). UNEP is also involved in various regional projects.

### **8. Cross-border movement of hazardous wastes**

Cross-border movement of hazardous wastes refers to the growing problem of waste being transported from the country of origin across international borders, principally as a result of high waste-processing costs or insufficient processing capacity in the producer country.

This issue has become a global environmental problem because the mechanism of waste generation frequently results in highly toxic wastes that, in many cases, are not treated appropriately in the receiving country. This leads to a multitude of serious instances of environmental pollution.

Investigation of the issue by UNEP and other bodies resulted in the adoption of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989), which stipulates rules concerning the transport of hazardous wastes across borders and their proper disposal. The convention aims to prevent environmental pollution by ensuring that hazardous waste transport and disposal are both managed properly. Japan is a signatory to the Basel Convention and has also enacted domestic legislation covering the import and export of specified types of hazardous waste.

### **9. Environmental issues in developing countries**

Pollution and other environmental problems are becoming increasingly serious issues in the developing world. Rapid industrialization and urbanization is causing atmospheric pollution and degrading the quality of the water supply, while mismanagement of environmental resources is leading to deforestation. The underlying causes are typically failure of the social infrastructure (traffic systems, water sewerage and sanitation systems, trash disposal facilities, and so on) to keep up with exploding population growth and the rising concentration of people in major population centers, combined with a lack of effective environmental standards and poorly functioning legal or monitoring systems. Many developing countries also lack the necessary capital, human resources, technology, and experience. Limited in what they can accomplish on their own, many nations are dependent on the help provided by international bodies and developed countries. A final problem is that the appropriate environmental actions, such as installation of equipment to cut pollution, are often not high on the priority lists of small countries. International cooperation spearheaded by economically developed nations is required to help developing countries solve environmental pollution and related problems in a way that is compatible with sustainable development.

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## **The Kyoto Protocol**

### **1. Mechanism of global warming**

Global warming involves the elevation of ground temperatures on the Earth as the result of rising atmospheric concentrations of various GHGs, chiefly carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), ozone (O<sub>3</sub>) in the troposphere, and CFCs. The mechanism by which this occurs is as follows.

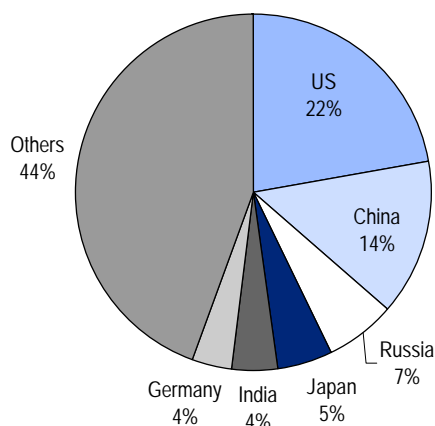
The atmosphere and the surface of the Earth together absorb about 70% of the energy contained in incident sunlight, in the process converting it to heat. At the same time, GHGs within the atmosphere absorb part of the infrared radiation emitted from the Earth's surface, which helps to regulate ground temperatures. Human activity, however, has upset this balance by causing a sharp increase in the concentration of atmospheric GHGs, and this is resulting in higher ground temperatures as infrared radiation is trapped (the greenhouse effect.)

*How global warming leads to elevated ground temperatures*



If CO<sub>2</sub> emissions remain at current levels, the ground temperature is projected to rise to a level almost double that prior to the industrial revolution by the end of the 21st century, according to a report by the Inter-Government Panel on Climate Change (IPCC). The report also predicts a rise in average global temperatures over the century of approximately 2°C, with certain regions possibly experiencing even sharper increases in temperature. Finally, the report forecasts a rise in sea levels of approximately 50cm over the same time frame.

FIGURE 1. CO<sub>2</sub> EMISSIONS BY COUNTRY (TOTAL CO<sub>2</sub> EMISSIONS: 6,213MN TONS)



Source: Japan Ministry of the Environment, based on 1996 data published by Oak Ridge National Laboratory.

**Kyoto Protocol debate  
focused on if it would  
come into force in 2002**

## 2. Outline of the Kyoto Protocol

The UN Framework Convention on Climate Change took legal effect in 1994, with the stated aim of the agreement being to stabilize GHG concentrations in a bid to stop global warming. From the outset, it was agreed that the convention was just an umbrella agreement that merely provided a framework for achieving related goals. Signatory nations understood that the specifics of quantitative targets, operational rules, and individual country obligations would all be stipulated in separate protocols, each of which would have to be subsequently ratified by each signatory.

The Kyoto Protocol was adopted in 1997 at the 3rd Conference of the Parties to the UNFCCC (COP3). The main points incorporated into the Kyoto Protocol are summarized below.

- Acceptance by developed countries of legally binding, numerical GHG emission control targets, as individually specified in the protocol
- Introduction of an international cooperative framework to facilitate target achievement
- Joint implementation of emissions trading and clean development mechanisms
- No quantitative performance targets or other obligations imposed on developing nations
- Targeted GHGs: CO<sub>2</sub>, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF<sub>6</sub>)
- Carbon sinks: Introduction of GHG absorption volumes for sinks that can potentially absorb emissions, such as forests
- Baseline year for emissions: 1990 (1995 allowed for HFCs, PFCs and SF<sub>6</sub>)
- Target achievement period: 2008–2012
- Numerical targets: Reductions in each country of 6% (Japan), 7% (US) and 8% (EU)
- Goal for developed nations as a whole of a minimum reduction of 5%

- Protocol to take effect once it is ratified by at least 55 signatory nations the aggregate GHG emissions of which equal at least 55% of total emissions

In 1998, an action plan was adopted at the COP4 meeting held in Buenos Aires, Argentina, in an attempt to accelerate implementation of the agreement by formulating specific operational plans that might encourage further protocol ratification. The US cast doubt on the scientific basis of the emission reduction goal-setting methodology, however, and protested at the fact that developing nations faced no obligation to reduce emissions. The US stated that it would not ratify the Kyoto Protocol, citing detrimental effects on the US economy and an energy crisis. This declaration prompted fears that the entire Kyoto Protocol could be rendered meaningless because, in 1996, the US accounted for some 22.2% of global CO<sub>2</sub> emissions. Attention has since switched to the Japanese government to see whether it might seek to persuade the US to change its position.

## The heat island phenomenon

*Ground temperatures in inner urban areas rising year after year*

The heat island phenomenon has been observed in several cities in Japan. It involves an elevation of air temperatures in city centers relative to suburban areas as a result of ground alteration processes, such as paving of surfaces and building construction, which mostly reflect the forces of urbanization. Such processes induce changes in the balance of heat at ground level in cities. The overall effect has been particularly noted in summer, when air temperatures are highest.

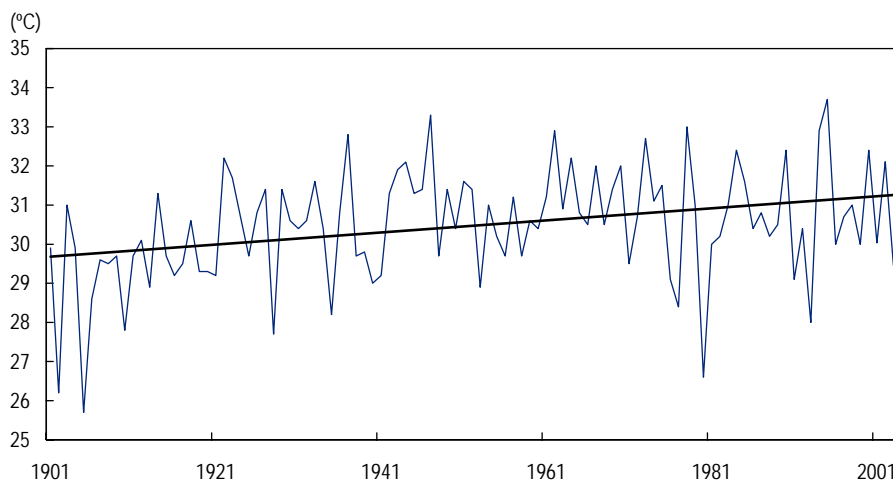
The cause of the phenomenon is a decrease in land occupied by water or greenery combined with an increase in the amount of paved surfaces and artificial objects, all of which are attributable to urbanization. Greater use of air conditioners also contributes to higher artificial heat generation. These factors disrupt the thermal balance at ground level and result in an accumulation of heat within the city.

One of the main effects of the heat island phenomenon is that cities become uncomfortably hot during the summer. This drives up electricity consumption to power cooling devices. Another consequence is that the changes to ground-level surfaces reduce the amount of natural evaporation, which creates a drier environment. As the city dries out, this not only creates the nuisance of increasing amounts of dust and other fine particulate matter swirling around, but it also prevents ground absorption of pollen grains, thereby exacerbating such medical conditions as hay fever. A final problem is the prolongation of air pollution effects in winter.

Peak temperatures in Tokyo have trended upward over the past 100 years, rising by nearly 2°C (Figures 2–3). The increase has been steepest in the past three decades. Average daytime lows at the height of summer have risen by around 3°C, to 24°C from 21°C around 1900.

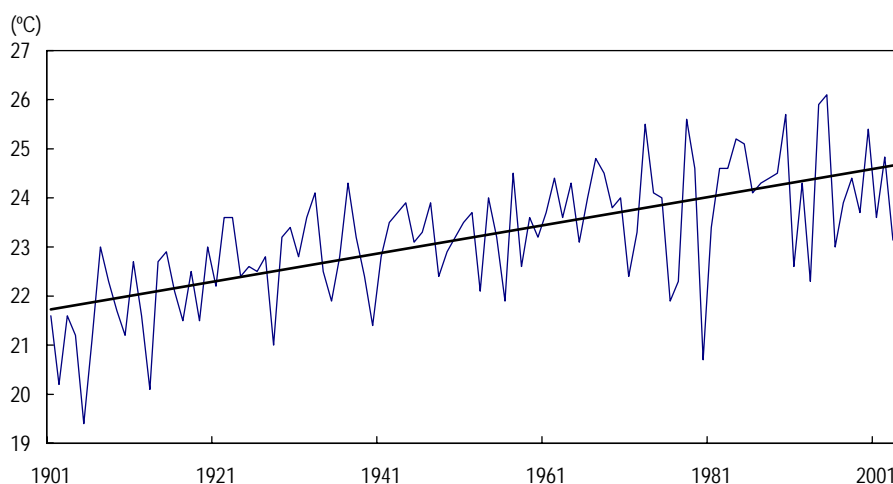
Extrapolations suggest that average daytime highs in Tokyo could reach 34.2°C by August 2100, assuming that current trends persist. Statistically, this means that there is a significant likelihood that by that time the temperature would exceed 40°C during August on at least one or two occasions. Rising temperatures are not the only problem: the threat of torrential downpours centered over the city would also be magnified. A large supply of heat from a city tends to promote the creation of thunderclouds, potentially spawning “super-cell” storm systems capable of generating huge quantities of rain. Recent recorded downpours in the Tokyo metropolitan area include one that dumped 114mm of rain on Minato Ward in August 1998 in just one hour and a 107mm soaking suffered by Itabashi Ward in July 2001.

**FIGURE 2. CHANGES IN AVERAGE AIR TEMPERATURE HIGHS FOR TOKYO IN AUGUST (1901–2003)**



Source: Japan Meteorological Agency.

**FIGURE 3. CHANGES IN AVERAGE AIR TEMPERATURE LOWS FOR TOKYO IN AUGUST (1901–2003)**



Source: Japan Meteorological Agency.

Japan’s Ministry of the Environment (MoE) has proposed the following measures that it says are required to curtail the heat island phenomenon.

**1. Reductions in artificial heat generation**

- Energy-efficient facilities: Optimal use of energy-efficient equipment; appropriate use of air-conditioning systems of increased efficiency
- Improved buildings: Reduced thermal load through improved insulation (better use of insulating materials and glass) and increased use of moisture-retentive materials
- Greater use of natural and under-utilized energy
- Greater use of solar energy and natural ventilation
- Localized measures: Construction of local air-conditioning systems; reduced city traffic through use of traffic demand management systems and promotion of bicycle use

**2. Improvements in ground-level surface coverings**

- More greenery

- Use of improved paving materials
- Improvements to vertical surfaces of buildings
- Measures to preserve water levels

### 3. Improvements in city design/infrastructure

- Greater use of natural wind and water channels
- Create cities adapted to eco-friendly energy sources
- Create cities designed around recycling-oriented concepts

## The environment and the market economy

### 1. Can the environment be compatible with the market economy?

*Companies that embrace environmental issues will be the winners*

Society thus confronts a wide variety of environmental issues, such as global warming. The issues involved not only have to be solved internationally, but they are also inextricably associated with corporate activities and consumer lifestyles.

Many companies to date have regarded efforts to tackle environmental issues as activities that simply expand their cost base in the face of market competition. Their initial response has often been to demand regulation and protection from governments to shield their businesses. We think, however, that concern for the environment can be a source of profits in itself.

Recycling systems, LEVs, and solar power are all examples of industries that prove this point. All have progressed as advances in terms of both regulatory developments, and technological innovations have resulted in higher productivity helping to correct an initially high cost base. Competition within each industry has acted as a further spur, in the process boosting the competitiveness of the entire sector. That is, environmental impact has become a direct source of added value, which has given rise to new business opportunities.

At the consumer level, awareness of environmental issues is on the rise. Products and services that use environmental impact as a source of profit are stimulating latent demand among the more eco-conscious consumers and investors, opening the way to new demand creation.

Our conclusion is that companies that view environmental issues and economic development as two halves of some kind of insoluble paradox will not benefit from environmental business opportunities. On the other hand, those industries or companies that embrace environmental issues stand to benefit greatly in growth terms, in our view. In particular, we think the potential opportunities presented by the restraints placed on the energy sector by environmental considerations will create entire new markets featuring novel technologies. We believe this promises to be a boon not just for existing firms but also for many new entrants.

### 2. Results of analysis by METI Council on Industrial Structure Committee on New Growth Industries

*Environment/energy market in Japan forecast to grow to ¥55trn by 2010*

On July 24, 2001, the METI Council on Industrial Structure Committee on New Growth Industries released its interim findings on policies to promote new growth industries in the Japanese economy. The report looked at the main goods and service sectors that are expected to develop strongly in Japan over the next 10 years and provided estimates of potential market sizes. Particular mention was made of 1) eco-friendly products and 2) intermediates and capital goods in the environment/energy sectors. In July 2002, the subcommittee released another interim report that provided case studies of promising new and growth industries. This report cited a number of emerging core technologies in the environment/energy sector, such as hybrid vehicles, solar power, and fuel cells, as well as various environmentally conscious products and processes, including recycled products and alternative refrigerants to replace CFCs.

The mass introduction of LEVs (including hybrid, LNG-powered, and electric vehicles) is one of the leading commercial prospects in the development of eco-friendly products. The market for LEVs in Japan is projected to expand to ¥5.2trn in 2010 from ¥1.1trn in 2000. There are a number of emerging growth possibilities in the area of intermediates and capital goods in the environment/energy sectors, as outlined below.

- Environmental materials: Insulators, filtration membranes (filters, water treatment)
- Environmental analyzers to assess air pollution and water quality
- Anti-pollution and emission-control equipment to curb CO<sub>2</sub> emissions, or to prevent air pollution, water pollution, and dioxins
- Waste-processing equipment for urban and industrial waste disposal
- Recycling equipment for cars and home appliances
- New energy-supply technologies based on sunlight, solar thermal power, biomass, or fuel cells
- Eco-friendly energy-supply technologies (e.g., energy-efficient air-conditioning systems, or electric power generation based on urban trash recycling)
- “Eco-materials,” such as biodegradable plastics and tree-free paper

The total environment/energy market in Japan is projected to grow to ¥55trn by 2010 from ¥22trn at present.

**FIGURE 4. PROSPECTIVE GROWTH INDUSTRIES IN THE ENVIRONMENT/ENERGY SECTOR**

(¥trn)	2000	2010E
Low-pollution vehicles	1.1	5.2
<b>Total</b>	<b>1.1</b>	<b>5.2</b>
	<b>1998</b>	<b>2010E</b>
Antipollution equipment	1.1	1.5
Waste disposal and recycling equipment	0.6	10.4
Facility construction (reclaimed areas)	0.2	0.0
Environmental restoration and creation	1.7	5.1
Environment-related services	0.2	0.7
Sewage treatment	0.1	1.2
Industrial waste recycling	16.7	28.3
Eco-materials	0.1	0.4
New energy sources	0.1	2.0
<b>Total</b>	<b>20.8</b>	<b>49.6</b>

Source: Interim reports (July 2001/July 2002) published by the Council on Industrial Structure Committee on New Growth Industries (METI).

The METI Committee on New Growth Industries stressed in these reports the need for the Japanese government to deregulate and to institute demand development programs in those areas with the most promising growth prospects. Where environmental issues are involved, the reports discussed the importance both of deregulation and of providing varied assistance to boost technological progress and to particularly encourage the development of a more energy-efficient society. Policies advocated in the reports ranged from boosting the development and introduction of microeconomic-power and other localized power generation systems to promotion of LEV usage and development. The reports also urged the public sector to take a lead in various eco-purchasing initiatives and to institute policies that favor the adoption of energy-saving technologies and innovative energy solutions in such areas as urban and residential development. In certain technology areas in which there is a fundamental need to make environmental requirements more compatible with economic imperatives to kick-start industrial and market creation, the reports advocated 1) the use of tax incentives and development subsidies to encourage companies to invest in environmental projects and 2) efforts to stimulate demand for new market creation.

Below is a list of the leading Japanese firms with a presence in various environmental sectors.

### 1. Oil and gas development

- Natural gas, oil plants  
JGC, Chiyoda Corp., Toyo Engineering, Mitsubishi Heavy Industries (MHI)
- Natural gas and oil production  
Nippon Oil, Mitsubishi Corp., Mitsui & Co., Itochu Corp.
- Oil tankers and LNG carriers  
MHI, Hitachi Zosen, Ishikawajima-Harima Heavy Industries, Mitsui Engineering & Shipbuilding, Kawasaki Heavy Industries (KHI), JFE Steel
- Pipelines and seamless pipes  
Nippon Steel, Sumitomo Metal Industries, JFE Steel

### 2. Energy supply

- Natural gas  
Tokyo Gas, Osaka Gas, MGC
- Oil refining  
Nippon Oil, TonenGeneral Sekiyu, Showa Shell Sekiyu
- Gas-fired power generation  
Tokyo Gas, Osaka Gas
- Electric utilities  
Tohoku Electric, Kyushu Electric

### 3. Emerging power generation technologies

- Nuclear power reactors  
Hitachi, Toshiba, Mitsubishi Electric (MELCO), MHI
- Microturbines  
MHI, Takuma, KHI, Toyota, Meidensha
- Fuel cells  
Toshiba, MELCO, Ebara, Toyota, Fuji Electric
- Solar power  
Sanyo Electric, Kyocera, Sharp

### 4. LEVs

- Hybrid vehicles (gasoline engine + battery-powered electric motor)  
Toyota, Honda
- Fuel-cell electric vehicles (FCEVs)  
Toyota, Honda, Mazda Motor
- Dimethyl ether (DME)  
JGC, MGC, MHI, Itochu Corp.

In the following sections, we examine natural gas and fuel cells, two areas in which developments are producing some of the most promising environmental technologies and products.

## Natural Gas

- **We view natural gas development as currently being positioned to have the greatest impact on equities of all promising environmental technologies**
- **The advantages of natural gas are as follows: 1) a clean profile; 2) a current potential supply (proven reserves/annual production) of over 60 years (40 years longer than oil); and 3) low Middle East dependence, as the region only accounts for one-third of proven reserves, against two-thirds for oil**

*Natural gas is growing globally as a clean form of energy*

### Natural gas: A clean form of energy

We feel natural gas development is currently positioned to have the greatest impact on equities of all promising environmental technologies. It has the following various advantages over oil: 1) a clean profile; 2) a current potential supply (proven reserves/annual production) of over 60 years (some 40 years longer than oil); and 3) relatively low Middle East dependence, as the region only accounts for one-third of proven reserves, against two-thirds for oil.

The development and consumption of natural gas as an energy source have tended to lag that of coal and oil owing to the high cost of the necessary development and production facilities. As concerns about environmental issues have mounted, however, attention has rapidly turned toward its increased exploitation. Over the years, it has made steady gains against other fuels in terms of its global share as an energy source for electric power generation (Figures 5–8). Currently, gas-powered electric power generation is a growth sector around the world, and we expect this growth to accelerate.

**FIGURE 5. GLOBAL ENERGY SOURCES FOR ELECTRIC POWER GENERATION**

	1980		1998		1998/1980 (x)
	Gigawatts	Pct of total	Gigawatts	Pct of total	
Coal	635	32.7	1,260	40.2	1.98
Hydroelectric power	459	23.6	678	21.6	1.48
Natural gas	169	8.7	495	15.8	2.93
Nuclear energy	134	6.9	359	11.5	2.68
Oil	540	27.8	311	9.9	0.58
Alternative energy sources	4	0.2	30	1.0	7.50
<b>Total</b>	<b>1,941</b>	<b>100.0</b>	<b>3,133</b>	<b>100.0</b>	<b>1.61</b>

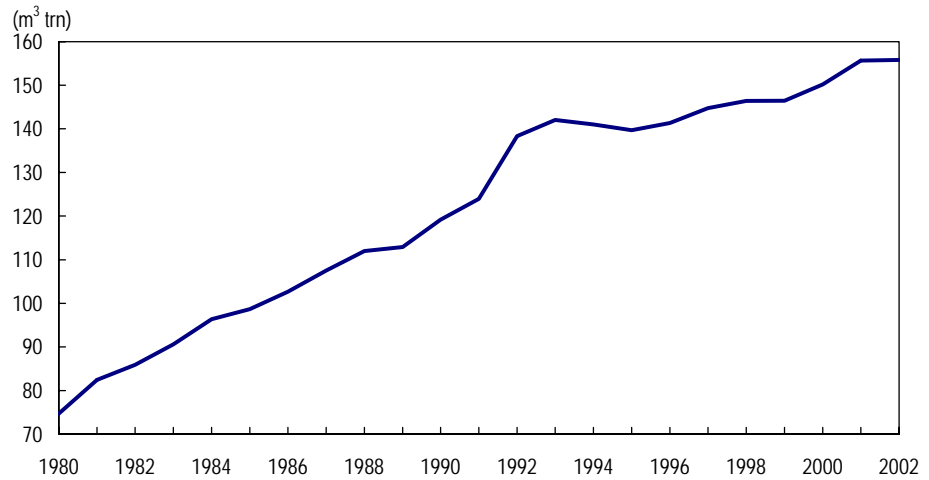
Source: World Bank, US Department of Energy.

**FIGURE 6. JAPAN'S PRIMARY ENERGY SOURCES**

(10bn KCAL)	Total supply	Oil	Share (%)	Coal	Share (%)	Nuclear	Share (%)	Natural gas, LNG	Share (%)
1990	459,216	268,284	58.4	78,542	17.1	43,778	9.5	48,375	10.5
1991	474,950	271,790	57.2	82,267	17.3	46,957	9.9	51,652	10.9
1992	481,626	279,626	58.1	81,158	16.9	48,834	10.1	52,905	11.0
1993	493,211	279,090	56.6	82,435	16.7	55,734	11.3	53,197	10.8
1994	512,934	296,290	57.8	84,990	16.6	58,106	11.3	57,074	11.1
1995	525,428	294,770	56.1	88,945	16.9	64,548	12.3	57,765	11.0
1996	536,414	296,444	55.3	91,334	17.0	66,712	12.4	62,532	11.7
1997	546,123	299,809	54.9	91,973	16.8	72,259	13.2	61,185	11.2
1998	529,494	278,044	52.5	90,997	17.2	73,344	13.9	63,985	12.1
1999	536,768	281,811	52.5	93,768	17.5	71,379	13.3	69,236	12.9
2000	547,572	282,549	51.6	100,891	18.4	71,801	13.1	72,056	13.2
<b>Share change (1990–2000)</b>			<b>-6.8</b>		<b>1.3</b>		<b>3.6</b>		<b>2.6</b>

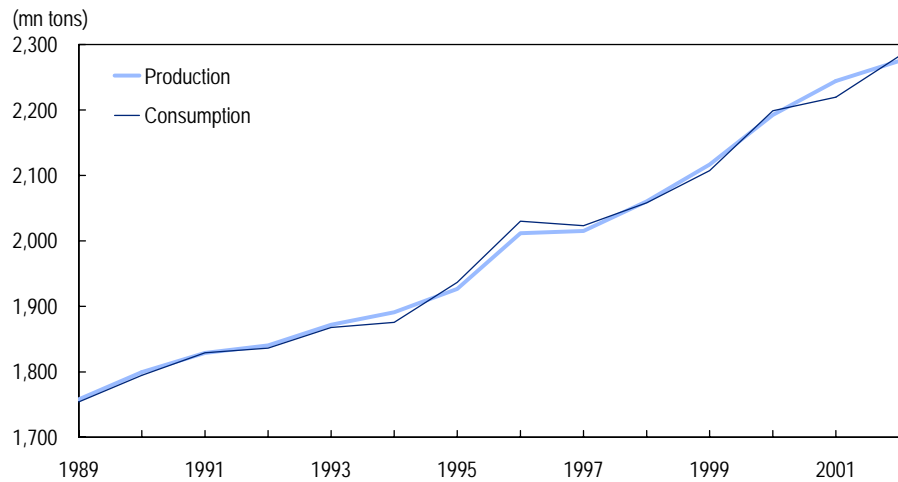
Source: Agency for Natural Resources and Energy.

**FIGURE 7. PROVEN RESERVES OF NATURAL GAS (1980-2002)**



Source: BP.

**FIGURE 8. PRODUCTION AND CONSUMPTION OF NATURAL GAS (1989-2002)**



Source: BP.

### Natural gas development

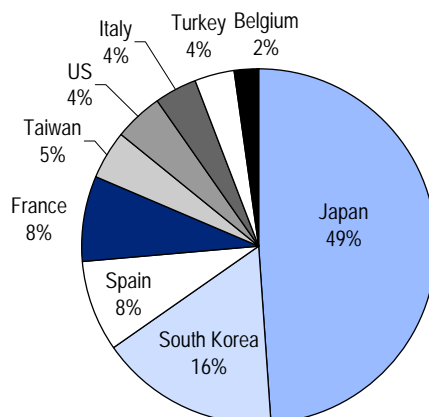
**We feel companies in the LNG field stand to benefit**

Countries typically import natural gas either through pipelines or by means of supply networks that store and transport the gas in its liquefied form, LNG. Many Western nations established their own national and regional pipelines to transport natural gas to areas of consumption in the 1960s. The subsequent growth in demand enabled the construction of long-distance pipeline supply networks, and these pipelines currently carry 90% of the supply.

The lack of any large-scale natural gas fields has forced Japan to rely on imports of LNG by sea. Some 97% of the natural gas used by Japan is imported through a domestic network of 23 LNG supply bases (a small amount is also produced within the country). Japan accounts for about half of all imports of LNG worldwide.



**FIGURE 9. LNG IMPORTS BY NATION (2002)**



Source: BP.

Japanese companies that we believe are best placed to benefit from an increase in global natural gas development are JGC and Chiyoda, which are global leaders in LNG plant engineering. In the global market, JGC commands an approximate 40% share in conjunction with US firm Kellogg, Brown & Root (KB&R), and Chiyoda Corp. has a share of approximately 25% (Figure 11).

The fact that LNG plants must handle LNG at  $-160^{\circ}\text{C}$  grants this sector a high technical barrier to entry. The market is quite distinct from that for petrochemical plants, and is dominated by JGC, KB&R, Bechtel, and Chiyoda. These companies are also involved in the development of a stream of related new technologies, such as gas-to-liquid (GTL) and technologies associated with the use of DME, the raw material for hydrogen fuel. These efforts are helping to create an environmental business boom that enhances the natural gas sector's inherent growth potential.

GTL technology involves the processing of natural gas into synthetic gas, which can then be converted into synthetic gasoline by means of catalytic reactions. This fuel is expected to be one of the main candidates for powering fuel-cell vehicles due to its 1) superior eco-friendly profile, 2) excellent combustion characteristics, and 3) suitability as a fuel for internal combustion engines that can be supplied using the existing gasoline infrastructure.

DME is a new candidate fuel for reforming to produce hydrogen. As such, it can maintain a link with primary fossil fuels, such as natural gas, coal, coal gas or oil. It is a cleaner and less toxic fuel than methanol. Its similar physical characteristics to liquefied petroleum gas (LPG) make it suitable for supply through the LPG infrastructure (used extensively by taxis in Japan). Its use is projected to expand as a fuel for various industrial and transport applications.

MHI is another firm that we feel stands to benefit in this area, as it is one of the world's leading constructors of LNG carriers. MHI could be one of the earliest gainers out of all the Japanese companies operating in power technology sectors. All of the major players in the energy sector are planning to raise their capital investments, which we believe implies gains for the most competitive firms in the LNG and oil plant construction field.

**FIGURE 10. PRINCIPAL JAPANESE COMPANIES WITH NATURAL GAS OPERATIONS**

Natural gas exploration, transport-related equipment manufacturing (LNG plants, pipelines, LNG ships)
JGC, Chiyoda Corp., MHI, Nippon Steel, Hitachi Zosen
Natural gas processing (gas chemistry)
MGC
Gas power generation equipment (heavy machinery)
MHI, Ishikawajima-Harima Heavy Industries, KHI
Gas supply (gas companies, electric power companies, trading companies)
Tokyo Gas, Osaka Gas
Natural gas exploration companies (trading companies, oil companies, gas exploration companies)
Mitsubishi Corp., Mitsui & Co., Itochu Corp., Nippon Oil, Teikoku Oil, Kanto Natural Gas Development

Source: Nikko Citigroup Limited.

Please note that the firms discussed below are not in our coverage, nor are the comments offered or intended as recommendations. The section simply introduces a number of Japanese firms the businesses of which we feel are at the nexus of rising environmental concerns and the emerging issue of energy supply inadequacies.

**JGC**

*World's leading builder of LNG plants, also focusing on new areas, such as GTL and DME*

JGC is one company that stands to gain both directly and in the short term from expansion of clean energy development, owing to its leading global share of the LNG plant construction market. As concern over environmental issues continues to rise, there is a possibility that the pace at which natural gas is gaining share among primary energy sources will step up a notch. Capex in the energy sector is still deriving some rebound benefits after capital spending dropped in 1998 and 1999 following the sharp drop in energy prices during 1997. The change in energy policy within US government circles is also exerting a positive effect.

We think rising capital investment will benefit highly competitive constructors of LNG and oil plants. We feel that, given its leading position in the development of new natural gas and related technologies, such as GTL and DME (being developed jointly with MGC), JGC is likely to attract favorable attention as a pioneer of clean energy.

**FIGURE 11. LNG PLANT: GLOBAL MARKET SHARE**

JGC, KB&R	About 40% (22 projects, 40mn tons of capacity)
Chiyoda Corp.	About 25%
Bechtel Group	About 20%

Source: JGC.

**MHI**

*MHI likely to benefit from gas turbines; operations also span various other power technologies*

MHI is a high-tech enterprise with operations spanning many areas of power technology (Figure 12). The company's gas turbine operations have world-class technologies, and MHI is making steady inroads into the North American market. Industry commentators have projected that the equivalent of some 1,300 midsize power plants need to be built over the next 20 years to eliminate the structural shortage of power generation capacity in the US alone. Given this situation, construction of eco-friendly, gas-fired power plants that use gas turbines is understandably expected to increase. MHI has established a local subsidiary in North America to oversee service functions for its gas turbine division along with its prime mover operations; this firm commenced operations in 2001.

**FIGURE 12. MHI'S POWER TECHNOLOGIES**

Short-term (1-2 yrs)	Gas turbine power generation, oil, LNG plants, LNG ships
Medium-term (3-5 yrs)	Microturbines, fuel-cell batteries
Long-term (5-10 yrs)	Nuclear power plants, fuel-cell battery cars

Source: Nikko Citigroup Limited.

## Fuel-cell Vehicles (FCVs)

- **FCVs use internal electric motors powered by a fuel cell as the main source of motive power. Such motors are more eco-friendly than gasoline engines due to their superior fuel efficiency**
- **We think FCVs have the best long-term prospects of all environmental products and technologies. FCVs can potentially solve the problem of GHG emissions by internal combustion vehicles**
- **Fuel-cell manufacturers and car makers are the principal developers in the field; Toyota and Honda are both moving ahead with FCVs**
- **Fuel-efficient vehicles and LEVs enjoy preferential tax treatment in Japan (reduced purchase and license taxes), which we believe should help to encourage greater consumer take-up of such vehicles**

### FCVs: Why all the attention?

*At last, vehicles that are both clean and efficient*

We think that FCVs have the best long-term prospects of all environmental products and technologies. The two largest sources of GHG emissions are 1) electric power generation from oil and coal, and 2) gasoline-powered vehicles. Switching over to natural-gas-fired and nuclear power plants can help solve the first problem; FCVs can potentially solve the second.

The Kyoto Protocol was adopted at the COP3 meeting held in 1997. This agreement committed the leading developed nations to set targets for curbing GHG emissions over 2008–2012, and to tackle the problem of how to cut such emissions in each country. Although the protocol has yet to come into force, widespread efforts are being made to improve vehicle fuel economy and cut the amounts of CO<sub>2</sub> and other pollutants emitted by car engines. This is principally in response to green legislative initiatives in such places as California (zero-emissions vehicle [ZEV] rules came into effect in 2003) and Japan (an amended version of a law promoting energy saving was enacted in 1999).

Fuel-cell electric vehicles (FCEVs) not only provide timely solutions to new environmental problems, but are also receiving attention because they represent a substantial advance in terms of efficiency and thus present a feasible alternative to the current situation. A future shift has been projected from cars powered by engines that run on gasoline (which account for the vast majority of vehicles currently on the road) to ones that use a system powered by some kind of fuel cell. Naturally, any such revolutionary technology could have an enormous impact on the market were it successfully introduced.

The sheer size of the potential market has driven many companies and researchers to compete to improve and develop the relevant technologies. Lately, the pace of the competition has picked up. The hurdles of creating an efficient and eco-friendly system have essentially now been overcome, and the emphasis has shifted to improving automotive fuel-cell engineering technology to the point where the price of FCVs can fall to a reasonably commercial level. Once this happens, the sector, in our view, will be set to generate a great deal of growth. Thus, although all the stages of commercialization have not yet been completed, the market for FCVs from a long-term perspective is such that we feel investors cannot afford to overlook it. Below we take a closer look at FCVs and the future market for them.

## Fuel cells

*The fuel cell was actually invented in 1839*

Any discussion of FCVs demands some preliminary knowledge of fuel cells. Below we provide an outline.

### 1. Fuel cells: A resurrection of an old idea

A fuel cell is a device for generating electricity from some kind of fuel, such as natural gas, methanol, oil, coal gas, or biomass. The fuel cell makes direct use of an electrochemical process, the reverse electrolysis of water, which eliminates the need for the fuel combustion that is characteristic of conventional methods of electric power generation. The process is also highly efficient and eco-friendly, which is why fuel cells have gained attention. A final bonus feature of fuel cells is that they generate electricity in situ, rather than in large, centralized facilities. This on-site generational capability makes them highly suitable for micro-power.

In 1839, British amateur scientist Sir William Grove invented a machine that could produce electricity using a chemical reaction involving oxygen and hydrogen. This was the birth of the fuel cell. The technology made few further advances until NASA fitted a fuel cell onto the Gemini 5 spacecraft in 1960, at which point investment began to flow into the fledgling fuel-cell industry. Prior to this, General Electric had successfully developed proton exchange membrane (PEM) fuel-cell technology in 1950. Ballard Power Systems initiated its own R&D program in the 1980s. Developments made by Ballard have contributed significantly to the evolution of the fuel cell.

Several trends have served to propel the commercial development of the fuel cell in recent years: 1) demand for high-quality electric power has arisen as the economy has shifted over to digital technologies; 2) long-term under-investment in power plants has resulted in a lack of generating capacity; 3) concerns over environmental issues have come to the fore; and 4) diversification of energy supplies and a shift toward alternative sources have raised safety and security issues. In addition, the general intensification of competition within industry and the ability of fuel-cell technology to create whole new sectors have underlined the extremely large untapped potential of the market, which has helped increase interest in this technology.

### 2. Types of fuel cells

*PEM fuel cell dominates*

Most R&D dollars in the field are directed at the PEM fuel cell, although other varieties of fuel-cell technology are being commercialized. One player that has achieved success over the past 10 years is International Fuel Cells, a subsidiary of United Technologies Corp. (UTC), which has developed a phosphate fuel cell capable of generating 200kW.

NASA has also been using alkaline fuel cells manufactured by UTC in its space program for more than 20 years. Whereas PEM fuel cells need 100% pure hydrogen to work, other types of fuel cell can avoid this requirement by operating at more elevated temperatures. A total of five main types of fuel-cell technology are currently in worldwide development.

### 3. How does a fuel cell work?

*A chemical reaction of hydrogen and oxygen produces electricity*

Fuel cells are a means of producing the energy released by the reaction of hydrogen and oxygen (the reverse electrolysis of water) in the form of electricity. When hydrogen and oxygen react together directly, they normally burn to produce heat. In a fuel cell, this reaction occurs instead through the dissociation of electrolytes. In this way, the energy contained in the hydrogen can be converted into electricity rather than producing heat.

The electric power generation process in a PEM fuel cell is completely emission-free because the inputs are just hydrogen and oxygen and the only output is water. Although CO<sub>2</sub> is emitted if the hydrogen is generated through reformation of a fossil fuel, these emissions are restricted because the process can still extract energy much more efficiently than by the combustion of other fuels. The process can also be made zero-emission if the hydrogen is generated from renewable sources.

**Market could exceed  
US\$20bn by 2010**

#### 4. Size of the potential market for fuel cells

We project an annual market for fuel cells of approximately US\$11bn by 2010. Allied Business Intelligence forecasts a corresponding figure of over US\$20bn. The global market for on-site power generation is currently estimated at \$980bn. Given all the possible latent demand for alternative energy supply from homes, car owners, public institutions, commerce and industry, we think that even the US\$20bn figure cannot be dismissed as far-fetched.

Most of the companies operating in the fuel-cell field forecast being able to begin commercial product shipments during 2002–2005. Market acceptance of these products will doubtless take longer, in our opinion. Capstone Turbine launched its 30kW micro-turbines in 1998, but production and orders have only recently started to exhibit strong growth.

Most companies are remaining firmly non-committal about their various prototype models until they can demonstrate 1) lower prices from mass-production economies of scale and 2) positive product feedback. As a result, we expect initial take-up of fuel cells to be low, with only gradual market penetration by 2005; mass-market acceptance, in our view, will certainly be much later than this. Firms will first need to generate success stories to win consumers' trust.

**Various applications**

#### 5. Uses of fuel cells

Fuel cells have a variety of envisaged applications, including: 1) as installed, fixed power supply units for homes, commercial premises and light industry; 2) in back-up engines, as part of uninterrupted power supply (UPS) systems; 3) as a replacement for the internal combustion engine in cars; and 4) in portable devices, such as PCs and mobile phones. The market for fuel cells is thus likely to be segmented according to application. At this stage, our view is that the PEM cell will most likely take the vast majority of the market share in consumer applications, by virtue of its 1) compact size, 2) low operating temperature, 3) eco-friendly profile, and 4) the possibility of lower costs in the future as the result of a rapid increase in supply.

## Fuel-cell vehicles

**FCVs use fuel cells as  
their main source of  
motive power**

### 1. What is a FCV?

A FCV uses an internal electric motor as its main motive power source, with a fuel cell generating the necessary electric power. Fuel cells have higher combustion efficiency than internal combustion engines, particularly under partial loads. Fuel cells use a reaction involving oxygen and hydrogen to generate electricity. Water is the only emission from this process, as long as the fuel cell uses hydrogen as its fuel. If the hydrogen is generated through reformation of some kind of hydrocarbon fuel, such as methanol, CO<sub>2</sub>, NO<sub>x</sub>, and other emissions are still much lower than those produced by a conventional gasoline engine.

**Hybrid and direct  
powertrains**

### 2. Drive systems used in FCVs

FCV powertrains can be divided into two main types. Hybrid powertrains combine a fuel cell with a battery-powered system to drive the motor. Toyota has developed the Prius, a fuel-cell hybrid vehicle (FCHV), the battery system and hybrid powertrain of which have generated a great deal of interest. The advantage of an FCHV is that the battery supplies enough supplementary power to deliver high power output off a cold start; this system also ensures good acceleration. The second type of FCV powertrain is the direct type. In this set-up, the fuel cell drives the motor directly. DaimlerChrysler, among others, has adopted this model. The advantage of this approach is that the absence of a battery reduces weight and cost and also allows more cabin space.

**Gasoline reformation,  
methanol reformation,  
and hydrogen-on-board**

### 3. Fuel supply methods

Different FCV developers have also adopted varying methods of supplying the fuel.

The gasoline reformation approach produces hydrogen by reforming gasoline. The principal proponents of this model are Toyota and General Motors (GM). The main advantage of the gasoline reformation method is that it can use the existing gasoline supply infrastructure, so it can be combined with the continued use of gasoline engine-powered vehicles. The efficiency of hydrogen production is also greater than with methanol reformation. The difficulties with this approach are that 1) the reformation technology is more complex than with methanol, and 2) it ultimately relies on the development of cleaner gasoline. A final disadvantage from both the environmental and energy perspectives is that it does not sever the link of oil dependence.

DaimlerChrysler, Ford Motor, Honda, and Nissan are the carmakers in the methanol reformation camp. The process of reforming methanol to generate hydrogen can occur at a lower temperature than that needed for gasoline. Another plus is that methanol reformation helps lessen dependence on oil. The main problem is that pumping methanol into cars requires new infrastructure, so supply stability is a major issue. A separate drawback that cannot be overlooked involves the potential toxicity of methanol, which has been the subject of academic debate.

A third, entirely different, approach is the hydrogen-on-board method. Supplying hydrogen fuel directly to the fuel cell in an FCV could be accomplished in a number of ways: 1) using hydrogen gas compressed at high pressure; 2) using hydrogen liquefied at low temperatures; or 3) storing the hydrogen inside a special hydrogen-absorbing alloy. As the reaction inside a fuel cell between hydrogen and oxygen produces just water and electricity, any vehicle that employed such a hydrogen-on-board method would be the ultimate ZEV, a true eco-car. The main problem is that there is virtually no infrastructure for supplying cars with hydrogen.

All of these methods have their positive and negative points. Development of reformation technology is progressing with the carmakers essentially divided into two groups: the Toyota/GM alliance, which favors gasoline reformation, and a pro-methanol alliance led by DaimlerChrysler and Ford.

## Development status at key companies

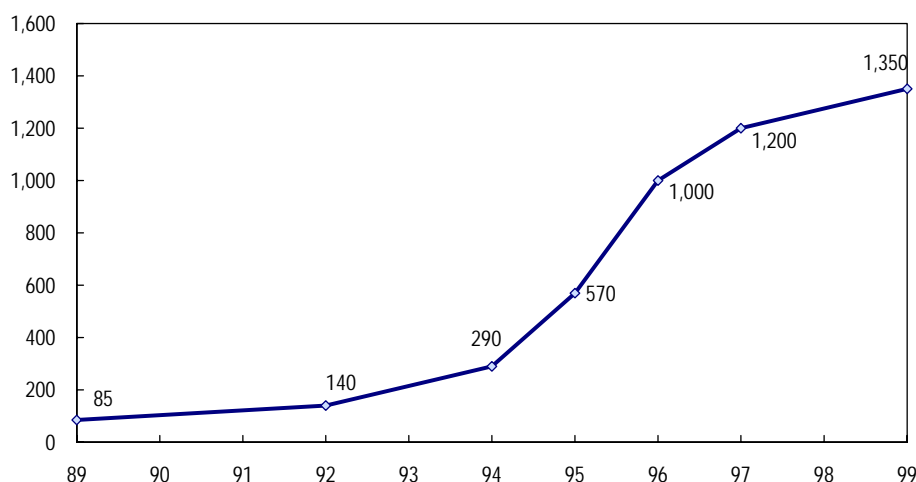
### GM

GM began full-scale development of FCVs around 1997, and its R&D program in this field is currently split between three facilities in the US and Europe. Development in the Asian market is being carried out jointly with Toyota. The US facilities are focusing more on components (reformers, fuel-cell stacks), while the systems and vehicle development is situated mainly in Europe (specifically, GM's wholly-owned subsidiary in Germany, Adam Opel). FCV fuel supply technology development is progressing along two tracks: GM is developing gasoline reformation technology in the US, while the European subsidiary is aiming to perfect a liquid hydrogen supply model. GM aims to be selling FCVs in commercial quantities by 2008–2010.

### Ballard Power Systems

Ballard of Canada is a specialist developer of fuel cells that was founded by venture capital in 1979. Ballard's in-house development program has focused almost exclusively on solid polymer fuel cells. Since 1997, Ballard has initiated capital tie-ups with DaimlerChrysler, Ford and other firms, and it is currently supplying fuel-cell stacks to several major automakers. Ballard has been a leader in boosting the performance of fuel-cell stacks, and its products have already passed the output density target of 1,000W/l specified by the US Department of Energy-led Partnership for a New Generation of Vehicles (PNGV). The latest models have a rated output density of over 1,300W/l. Ballard completed its first mass-production facility in October 2000.

**FIGURE 13. OUTPUT DENSITY OF FUEL-CELL STACKS (WATTS/LITER)**



Source: Energy (May 2001 edition).

**BMW**

BMW is developing a variant of hydrogen-on-board technology based on direct internal combustion of liquid hydrogen for a next-generation vehicle. The company is also developing solid polymer fuel cells with International Fuel Cells, as well as a solid-oxide fuel cell in conjunction with Delphi.

**Toyota**

Since initiating its own FCV development program in 1992, Toyota has produced a series of different prototype vehicles powered by fuel cells. In 1996, it has developed its own fuel cells, and later it exhibited a car featuring a hydrogen-absorbing alloy. In 1997, Toyota developed and exhibited another prototype FCV (passenger car) based on methanol reformation. In addition, it is jointly developing with Hino Motors a large fuel-cell hybrid bus fitted with a highly pressurized hydrogen tank, although there are as yet no plans to commercialize this model.

**4. Commercialization prospects**

While the potential market for FCVs is large, in the introductory phase, initial vehicle prices will be relatively expensive, and the running costs of fuel are also projected to be high. For these reasons, we believe that major market take-up of FCVs will not occur until around 2020. In the meantime, we see manufacturers making gradual progress toward the mass-market penetration of FCVs by 1) driving down the cost of vehicles via mass-production economies of scale; and 2) introducing a series of intermediate vehicles that combine an electric motor—possibly powered by a fuel cell—with a gasoline engine in some form of hybrid powertrain.

*Major market penetration projected around 2020*

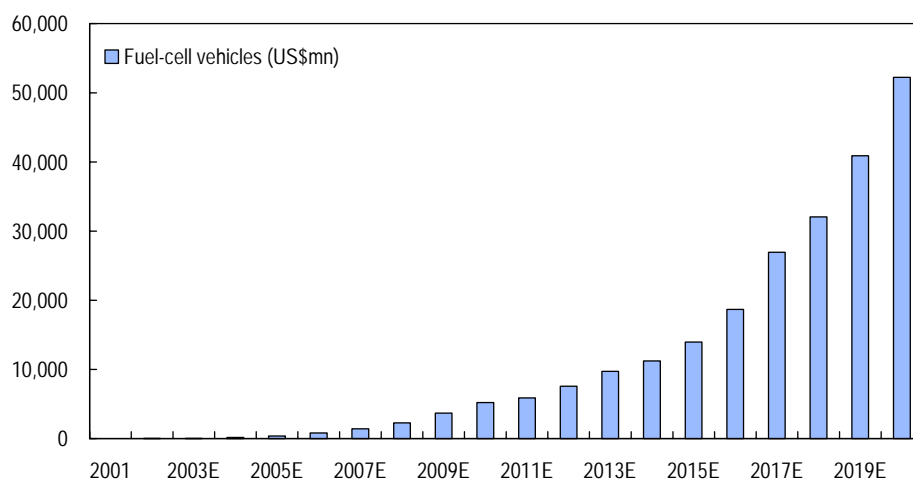
**FIGURE 14. FUEL-CELL PROJECTIONS BY MARKET**

	2005E		2010E		2015E		2020E	
	Value (US\$m)	Penetration rate (%)	Value (US\$m)	Penetration rate (%)	Value (US\$m)	Penetration rate (%)	Value (US\$m)	Penetration rate (%)
Auto	301	0.1	4,205	1.5	12,379	6.3	50,058	25
Bus, light truck	71	0.6	1,018	10.5	1,587	16.7	2,175	22.8
Portable	165	2.2	738	20.5	1,135	35	1,134	40
Stationary	1,398	0.2	6,720	0.3	16,040	0.4	21,496	0.5

Note: Penetration rates for stand-alone power applications apply to the global power generation market.

Source: Smith Barney.

**FIGURE 15. FCV DEMAND PROJECTION**



Source: Smith Barney.

**FIGURE 16. INTRODUCTION TARGETS FOR FUEL CELLS IN JAPAN (CUMULATIVE)**

	2010E	2020E
Fuel-cell vehicles	About 0.05mn	About 5mn
Stationary fuel cells	About 2.1mn KW	About 10mn KW

Note: Projections assume positive take-up of solid polymer fuel cells.

Source: METI (Research Group on Fuel Cell Commercialization Strategy).

**A hydrogen-supply infrastructure is needed in the long term**

A fuel-supply infrastructure is critical if FCVs are to gain widespread acceptance. Given the current lack of suitable infrastructure to support the adoption of the FCVs now in development, the most likely initial adoption route for hydrogen-fueled fuel-cell technology is in buses or garbage trucks that could operate in fleets within certain specified areas. Buses powered by hydrogen-fueled internal combustion engines already operate in Germany.

The existing gasoline-supply network would be able to support the commercialization of FCVs based on gasoline reformation in the shorter term. This would facilitate the operation of ordinary passenger FCVs as well as fleet vehicles. Over the long term, we can also expect the commercialization and take-up of FCVs fueled directly by hydrogen. Once FCVs can produce on-board hydrogen from a renewable energy source, they become ZEVs that do not emit any CO<sub>2</sub>. Hydrogen has the potential to become an important fuel of the future to supply fuel cells if the latter can be improved to 1) raise output levels, 2) eliminate the need for reformer units, 3) make the electrodes non-poisonous, and 4) boost cell durability. Ultimately, a large social investment in a hydrogen-supply infrastructure is required to make fuel cells directly fueled by hydrogen a realistic possibility.

**5. Government support**

**Development support plus tax incentives**

While the self-help efforts of the private sector are key to the future spread of FCVs, we feel there is also a role for governments to encourage early adoption at the current stage, when the initial costs imposed are highest. The PNGV program, which has operated in the US since 1993, has been involved in the development of automotive fuel cells.

Publicly funded business development programs in the US in this area involve seven federal government organizations (including the Department of Energy, the Department of Transportation, the Environmental Protection Agency and the National Science Foundation, under the leadership of the Department of Commerce), in conjunction with GM, Ford, DaimlerChrysler, and various universities and national research institutes. As part of the



California Fuel Cell Partnership (CFCP) program, the California Air Resources Board is introducing new regulations mandating ZEV-compliant status for at least 10% of new vehicles sold in California. The CFCP is not just a statewide program: Nissan, Honda, Volkswagen, GM, and Toyota have all announced their participation in related joint-testing programs. Thus, most of the leading FCV players are now involved.

Japan has introduced various incentives within the existing tax system to lower the costs of owning and operating vehicles that are either designated as LEVs or meet fuel economy standards. This preferential tax treatment is helping to encourage consumers to purchase LEVs and FCVs. Prime Minister Junichiro Koizumi has stated that all government-owned vehicles should be switched to LEV models, and this has led to a widespread move within central and local government to introduce LEVs. Such actions could hold the key to a similar shift toward LEVs among private vehicle owners in Japan.

# Investment Strategy and Recommended Stocks

- **We think growing environmental concerns and advances in power technology offer potentially large benefits to any companies in the field**
- **We highlight four Japanese firms that we believe stand to make large gains from power technology over the long term and also benefit in other sectors in the short term: Toyota, Honda, Mitsubishi Corp., and Tokyo Gas**

*Touching many sectors, power technology offers product-/period-specific distributed investment possibilities*

## Investment strategy

We think growing environmental concerns and advances in power technology offer potentially large benefits to any companies operating in the field.

Our fundamental investment strategy starts from a forecast rise in the short term in electric power plant construction demand in the US to correct undersupply there. This, we believe, will spur development in gas turbines, natural gas, and oil, which in turn should benefit companies that operate in oil and LNG plants. Medium-term strategic developments include the spread of micro-power and the emergence of gasoline-powered hybrid cars. Over the longer term, the main areas of our interest are FCVs and nuclear power generation.

### FIGURE 17. INVESTMENT TIMING

Short-term (1–2 years)	Gas turbine power generation, oil, LNG plants
Medium-term (3–5 years)	Microturbines, hybrid cars
Long-term (5–10 years)	Nuclear power plants, fuel-cell battery cars

*Source: Nikko Citigroup Limited.*

## Companies that stand to derive major long-term benefits

We highlight four Japanese companies that we believe stand to make large gains from power technology over the long term and also benefit in other sectors in the short term: Toyota, Honda, Mitsubishi Corp., and Tokyo Gas.

### Toyota

Toyota is a global leader in all aspects of LEV technologies. We believe that over the long term, the mainstream in vehicle propulsion systems will come to be occupied by hybrid systems that feature fuel cells and electric motors. Toyota is at the global forefront of the development of technologies that combine hybrid powertrains with high-pressure hydrogen fuel tanks. Although most of its current development efforts are directed toward gasoline-powered hybrid cars, its strategy includes a future switch to fuel-cell hybrids. We believe over the next 10 years we will see a major and rapid shift within the global car market, initially from gasoline-powered vehicles to gasoline-powered hybrids, and later to fuel-cell hybrids. As a technological leader in both these projected transitions, we feel Toyota could generate overwhelming competitive advantages.

*We recommend investors overweight Toyota, a global leader in LEV technologies*

**FIGURE 18. TOYOTA'S FCV STRATEGY SO FAR**

1992	Began developing fuel-cell vehicle (FCV)
1996	Develops hydrogen-absorbing alloy tank-type FCV
1997	Develops the world's first methanol reformer-type FCV
1997	Prius, the world's first hybrid car, goes on sale
2001	Estima, the world's first hybrid 4WD, goes on sale
	Plans to fit Mild Hybrid System in the Crown
Timing not set	Plans to develop high-pressure tank hydrogen-type fuel-cell hybrid bus in conjunction with Hino Motors

Source: Nikko Citigroup Limited.

## Earnings forecasts and share prices

### Honda

**A global leader in FCVs,  
fuel-efficient vehicles**

With its i-series engines, Honda is gradually improving environmental performance, both by cutting exhaust emissions and by reducing fuel consumption.

Like Toyota, Honda is moving forward at full speed to develop hybrid cars. The Civic hybrid launched in December 2001 incorporated new technologies that boosted the efficiency of Honda's hybrid Integrated Motor Assist (IMA) system. Honda's recent engine developments include 1) fuel-injected dual and sequential injection technology (i-DSI), which realizes more advanced lean-burn combustion; and 2) a cylinder timing modification to its variable valve timing electronic control (VTEC) technology, which improves fuel economy by allowing electrical energy to be recycled during deceleration (such energy could also be used to recharge a battery). Honda has developed a mass-produced gasoline-powered car capable of carrying five people that delivers world-class fuel economy of 29.5 km/l. In September 2001, the firm announced the development of its new FCV, the FCX-V4, and the company is currently taking part in the CFCP program in the US to test such models on public roads.

**FIGURE 19. HONDA: EARNINGS FORECASTS**

**Price (2/12): ¥4,500; FY3/05E PER: 10.1x**

	Sales		OP		RP		NP	
	¥mn	YoY (%)	¥mn	YoY (%)	¥mn	YoY (%)	¥mn	YoY (%)
FY3/03	7,971,499	8.3	689,449	7.8	609,755	10.6	426,662	17.6
FY3/04E	8,200,000	2.9	610,000	-11.5	635,000	4.1	460,000	7.8
FY3/05E	8,250,000	0.6	580,000	-4.9	580,000	-8.7	425,000	-7.6
FY3/06E	8,400,000	1.8	620,000	6.9	620,000	6.9	460,000	8.2

Source: Company data, Nikko Citigroup Limited.

### Mitsubishi Corp.

**Good prospects in the  
energy sector (as has  
Mitsui & Co.)**

Mitsubishi Corp.'s various LNG projects in FY3/01 accounted for an estimated 25% of its real consolidated NP that excludes capital gains. The company's MC2003 midterm business plan, which sets a target for consolidated NP of ¥120bn for FY3/04, unambiguously commits Mitsubishi Corp. to strategic investment in the resources and energy sector, a profitable area where the company considers itself highly competitive. The rights and interests that Mitsubishi Corp. owns in potential reserves of natural gas, crude oil, and condensate have an approximate current asset value of ¥5trn at market prices. Its potential future interests in various natural gas projects in which it is involved, such as Sakhalin II and Tangguh (Indonesia), are also considerable. New business development ventures include the following: 1) a capital stake in US firm Capstone, which is a leader in the micro gas turbine business; and 2) My Energy, a Japanese micro-power joint venture with Tokyo Electric Power (TEPCO), Tokyo Gas, and Nippon Oil. Mitsubishi Corp. is also involved in the GTL business together with Royal Dutch/Shell. We rate the profitability and growth potential of its other businesses highly, and we recommend the stock as a core holding in the trading company sector on the basis that, to us, it looks comparatively undervalued.

FIGURE 20. MITSUBISHI CORP.: EARNINGS FORECASTS

Price (2/12): ¥995; FY3/05E PER: 15.7x

	Sales		OP		RP		NP	
	¥mn	YoY (%)	¥mn	YoY (%)	¥mn	YoY (%)	¥mn	YoY (%)
FY3/03	13,328,721	0.7	100,639	47.6	60,834	-38.9	62,265	3.4
FY3/04E	14,800,000	11.0	125,000	24.2	150,000	146.6	100,000	60.6
FY3/05E	15,300,000	3.4	135,000	8.0	160,000	6.7	107,000	7.0
FY3/06E	15,800,000	3.3	150,000	11.1	172,000	7.5	116,000	8.4

Source: Company data, Nikko Citigroup Limited.

### Tokyo Gas

*Turning into a stable growth stock*

As a public utility, Tokyo Gas has gained an enduring image as a low-growth stock. The advent of deregulation and a transformation in the company's management outlook are now turning it into a stable growth stock, in our view.

Tokyo Gas is involved in both micro-power (micro gas turbines, co-generation systems) and the wholesale electricity market as a supplier through its new business development program. It is also rapidly advancing into LNG carrier construction (to secure a share of LNG distribution in Japan) and the natural gas business. Other factors supporting what we see as its high growth potential include 1) ongoing expansion of its service area, 2) the benefits of gas as a clean energy source, and 3) the company's improving finances.

Tokyo Gas plans to take advantage of deregulation to enter gas-fired electric power generation, which will bring it into greater competition with TEPCO. Given its competitiveness in this field, which is a major growth sector in Japan, we believe Tokyo Gas has the potential to gradually take market share from the electric utilities.

Demand for gas-powered cooling and air-conditioning systems is high in Tokyo, where the heat island phenomenon is most pronounced. This trend could help to close the gap between the firm's capacity utilization levels in summer and winter (gas usage has tended to be higher in colder weather), thereby boosting asset returns. In our view, Tokyo Gas has also taken a creatively assertive approach to risk management, such as the temperature-dependent indemnity contracts that it signed with TEPCO. Its management outlook is undergoing fundamental change, and we expect it to be only a matter of time before this is reflected in the share price.

FIGURE 21. TOKYO GAS: EARNINGS FORECASTS

Price (2/12): ¥412; FY3/05E PER: 15.7x

	Sales		OP		RP		NP	
	¥mn	YoY (%)	¥mn	YoY (%)	¥mn	YoY (%)	¥mn	YoY (%)
FY3/03	1,127,633	2.7	123,294	11.5	91,955	14.1	59,201	14.0
FY3/04E	1,166,000	3.4	148,000	20.0	126,000	37.0	80,000	35.1
FY3/05E	1,149,000	-1.5	135,000	-8.8	115,000	-8.7	72,000	-10.0
FY3/06E	1,158,000	0.8	138,000	2.2	120,000	4.3	82,000	13.9

Source: Company data, Nikko Citigroup Limited.

In the following sections, we discuss sectors of critical significance with respect to our environment-related investment themes. Our analysts covering the chemicals, consumer electronics, and pharmaceuticals sectors explore technologies, new products, and key firms as regards our central theme.

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## The Chemical Sector and the Environment

- **We present below an analysis by Takao Kanai of our chemicals team**
- **In response to problems with pollution, efforts by chemical manufacturers to clean up their gas emissions and wastewater and otherwise lighten the burden on the environment are showing results**
- **Changes in social consciousness about environmental problems, and legal system amendments present new business opportunities as evidenced by MGC's DME (dimethyl ether) business and Ube Industries' move into the environmental field**
- **Development of biodegradable plastic is progressing, and the market is gradually expanding**

### The chemical sector and global environment issues

#### The chemical industry and environmental problems

The chemical industry and environmental problems are inseparable. Taking to heart their experiences with Minamata Disease, Yokkaichi asthma, and other pollution problems previously experienced in Japan, chemical makers have invested heavily in cleaning up plant gas emissions and wastewater and moved forward with environmental measures. Currently, they have the world's highest environmental assessment level. For Japan to meet the Kyoto Protocol's goal of reducing warming gases (by 6% versus FY3/91 levels), the industry needs energy conservation on a par with those of the steel, paper, and other industries, and from the standpoint of energy consumption, we feel its measures are noteworthy. It has already made significant strides in this direction, and for further results to be shown in the period ahead, technological innovation will be required. This will not be easy, but with government subsidies, measures will be continuously implemented.

#### New business opportunities

We believe measures to lighten the burden on the environment are certain to become even more important. But many chemical makers see new business opportunities in terms of responses to greater social awareness of the problems and such legal system changes as laws requiring recycling of containers and packaging. Below we review MGC's DME business, Ube Industries' environmental segments and various companies' commercialization of biodegradable plastics as examples of how entrepreneur-oriented research has been conducted and actual businesses started.

### MGC's development of DME

#### Establishment of Japan DME

MGC established Japan DME in June 2001, together with JGC, MHI, and Itochu, with the objective of undertaking feasibility studies for entrepreneurs. Each of the four companies has a 25% stake, but Representative Director Hiromi Nakamura comes from MGC, and the latter's head office building houses DME's head office; it is thus leading these efforts.

*Spotlight on chemical makers' environmental work*

*We think MGC's DME business has long-term appeal*

### World leader in methanol technology

MGC is in the top class globally in methanol manufacture and derivative product technology. It has a stake in Saudi Arabia's Ar-Razi, the facilities of which produce 3.1mn tons/year using MGC's technology. It has a similar relationship with Venezuela's Metor, with a capacity of 730,000 tons/year. Leveraging its methanol expertise, the project for commercialization of DME occupies a central place in the company's plans.

### Clean energy

DME ( $\text{CH}_3\text{-O-CH}_3$ ), an ether, is a combustible gas similar to LP gas. Its distinctive characteristics are that, when burned, it gives off no sulfur oxides and soot and little nitrogen oxide. At  $-25^\circ\text{C}$ , its boiling point is higher than the  $-160^\circ\text{C}$  of liquid natural gas, enabling relatively low transport and storage costs. Further, because it has a high cetane rating (an indicator of ignitability of diesel and other fuels inside diesel machinery), it may be used as diesel fuel.

FIGURE 22. DME PROPERTIES

		Crude oil	LNG (C <sub>1</sub> )	Gas oil	Propane	Methanol	DME
Lower heating value	kcal/kg	9,850	12,180	10,150	11,040	4,750	6,880
	kcal/L	8,370	5,180	8,530	5,450	3,770	4,600
	kcal/Nm <sup>3</sup>	-	8,700	-	21,800	-	14,200
Fluid relative density	kg/L	-0.85	0.425	0.84	0.49	0.796	0.668
Cetane value		-	-	38-53	5	3	>55
Boiling point	$^\circ\text{C}$	-	-162	180-360	-42	65	-25
Fire point	$^\circ\text{C}$	-35	-	50-70	-	11	-
Ignition point	$^\circ\text{C}$	-	537	約 250	504	464	350
Air-fuel ratio	kg/kg	-	16.0	14.7	15.6	6.5	9.0
Explosion limit	Vol %	1-16	5-15	0.5-7.5	2.1-9.4	6.7-36	3.4-18

Source: MGC.

### Easier handling

The company's expectations for DME are based on 1) environment-friendly clean energy, 2) ease of handling, 2) greater economy and 4) many possible uses.

### Good emission properties

Regarding the first point above, company officials note that DME emits no SMP (soot and other particulates) and sulfur oxides, and only natural gas has less nitrogen oxide and warming effects. DME also has lower toxicity and can thus be used as a Freon substitute, it breaks down easily in the troposphere and is less corrosive to metals.

### Business takes the lead in gasification

Japan DME has an organization for conducting feasibility studies, and as the likelihood of commercializing these operations using local capital increases, we think it likely that these operations would be reorganized under the effective leadership of MGC. The company is studying commercialization with a target date of end-2006 for the start of operations. Plans call for construction of a plant in Western Australia's Dampier, with a daily output of 4,000–7,000 tons/day (1.4 tons–2.4 tons/year) using MGC's manufacturing processes. The outlook is for investment of \$500mn-\$600mn.

### A substitute for industrial LPG

The first market application under study is industrial LPG substitution. Just under 80% of the volume used domestically is imported, and of that, some 80% comes from the Middle East. DME's ease of handling enables the use of small gas fields in Australia and elsewhere, for source diversification. The resemblance of its properties to those of LPG enables use of

existing infrastructure and facilities, so this is an area in which operations can be up and running in a relatively short period. In the future, DME may be substituted for kerosene as a fuel Diesel engines, and it will thus require time for the preparation of regulations and infrastructure.

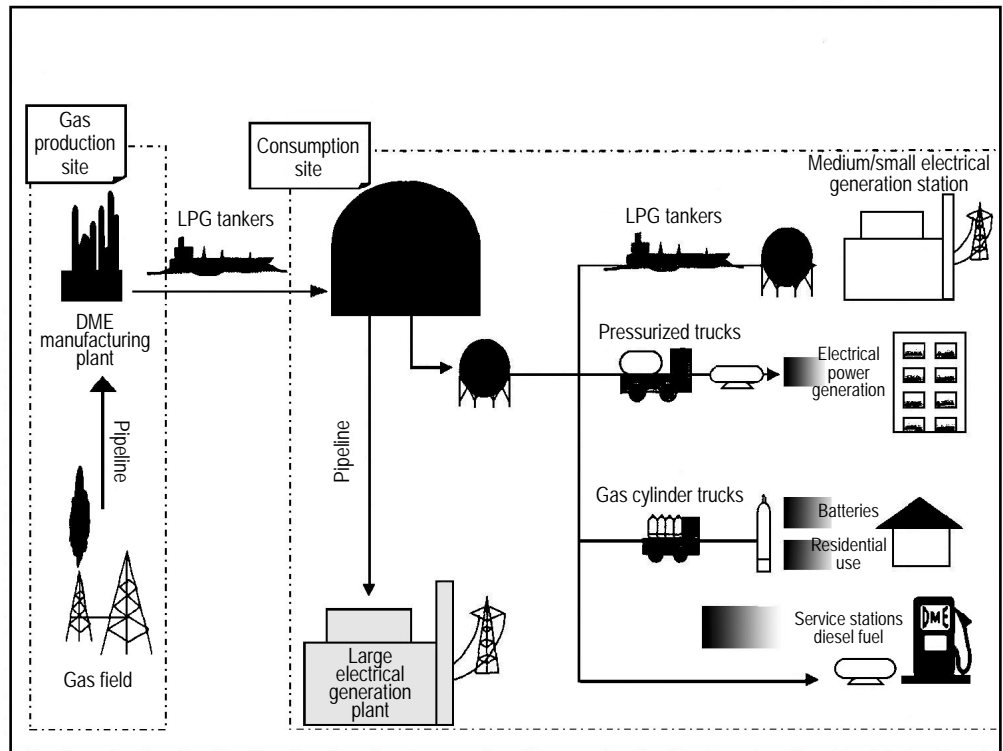
**Leveraging expertise in methanol production technology**

MGC possesses strengths in methanol manufacturing techniques that it can leverage in DME business development. In DME production, the direct synthesis and methanol dehydration methods are available, and the company’s policy is to use the latter. For manufacturing with methanol, it can use its advanced technologies. We think MGC can also benefit from techniques cultivated in its methanol business to handle large volumes of products.

**Long-term promise**

The issues the company considers in its DME business development include the confirmation of potential uses and safety, competitive plant location, securing business partners, and advantageous fund procurement. Management thinks there are still a number of issues to resolve to develop practical uses for this technology. However, as DME is a clean energy source and because it can be used to diversify energy sources, if a certain economically competitive level is reached, this field should have long-term promise.

FIGURE 23. DME TRANSPORTATION FLOW



Source: MGC.

**Ube Industries’ environmental business**

**Home prefecture is positive on environmental businesses**

Ube’s home base of Yamaguchi Prefecture is promoting the business. In the Yamaguchi ZE Plan, there are 64 projects under development, including construction waste recycling, automobile recycling, and garbage reduction and recycling. In the cities of Ube and Onoda, moreover, Yamaguchi University, Ube Industries, Chugoku Electric Power, and others have

*Ube Industries’ environmental business focuses on EUP, geomelt, and biomass operations*

forged industry/government/academic links for environmental technology and energy conservation measures.

### **Start of EUP business**

The two-stage gasification process (EUP) 50-50 joint venture established by Ube and Ebara in 2000 is an example of an application of this technology. Using gasified chemical recycling technology, vinyl chloride is crushed without prior separation, formed as tubular solid fuel (RDF), and gasified in two stages that use low- and high-temperature furnaces. This process enables heat decomposition, partial oxidation, and refining of hydrogen and carbon monoxide.

### **Complete zero emissions**

A major advantage of this process is that it produces no waste (i.e. zero emissions). Hydrogen and carbon monoxide can be used as materials for such items as ammonia as well as in fuel cells. The iron and nonferrous metals generated in the process are also usable as scrap, and inorganic matter can be used in such products as cement while such items as chlorine are recoverable as ammonium chloride (fertilizer). Further, after heat decomposition in the high-temperature gasification furnace instant cooling eliminates concerns about dioxin synthesis, and use of gas products as chemical feedstock also means lower usage volumes for petrochemical raw materials.

### **Ube's two systems**

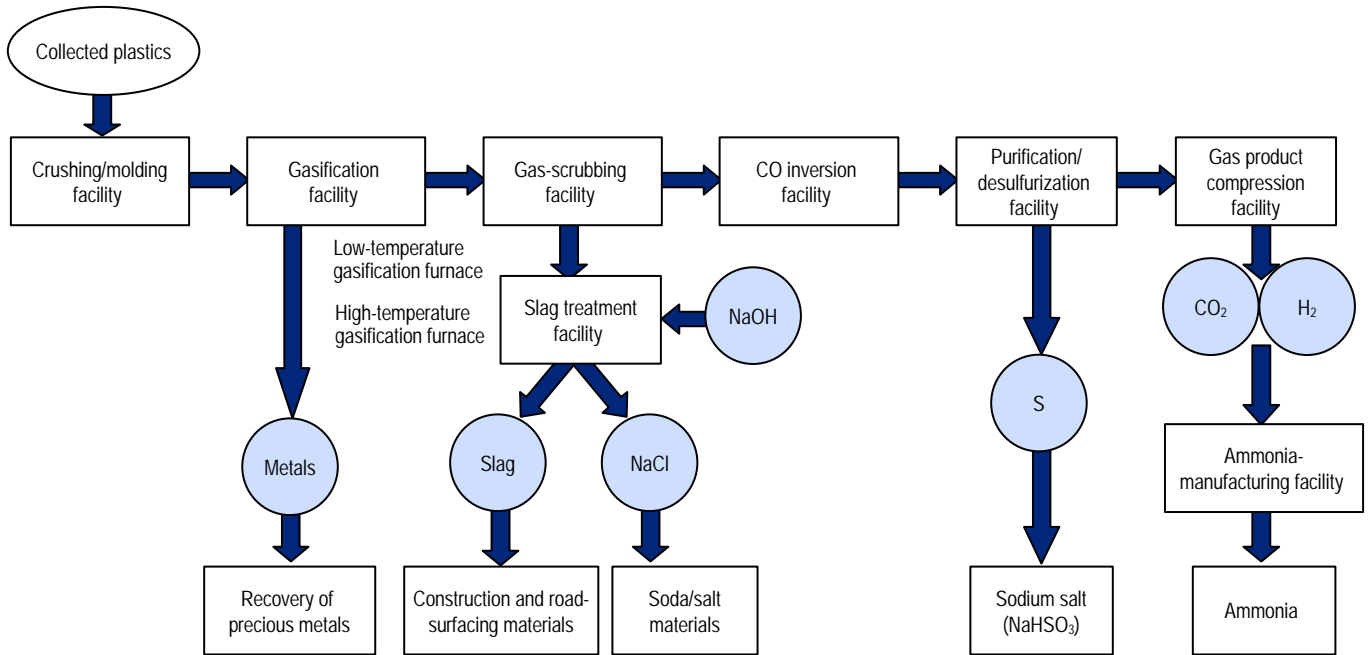
In Ube's plant, the No. 1 and No. 2 EUP systems are already in operation, with annual processing capacities of 30 tons/day and 65 tons/day, respectively. Ube Ammonia Industry can use the gas produced as a raw material.

### **Showa Denko introduces the system**

In October 2002, Showa Denko decided to enter the chemical recycling business using the EUP system, and a plant in Kawasaki is now operating. On a daily basis, the plant processes 195 tons of recovered plastics and produces 175 tons of liquid ammonia and other chemicals without producing any waste. This is in line with the basic Kawasaki Eco Town Concept policy and contributes to creation of a "circulating society" that completely recycles general and industrial waste plastics. Capex totaled ¥7.4bn, of which about ¥3.7bn came from subsidies from the central government and Kawasaki City. Showa Denko expects to reduce costs in this business by about ¥1bn.



FIGURE 24. EUP PROCESS OVERVIEW



Source: Showa Denko.

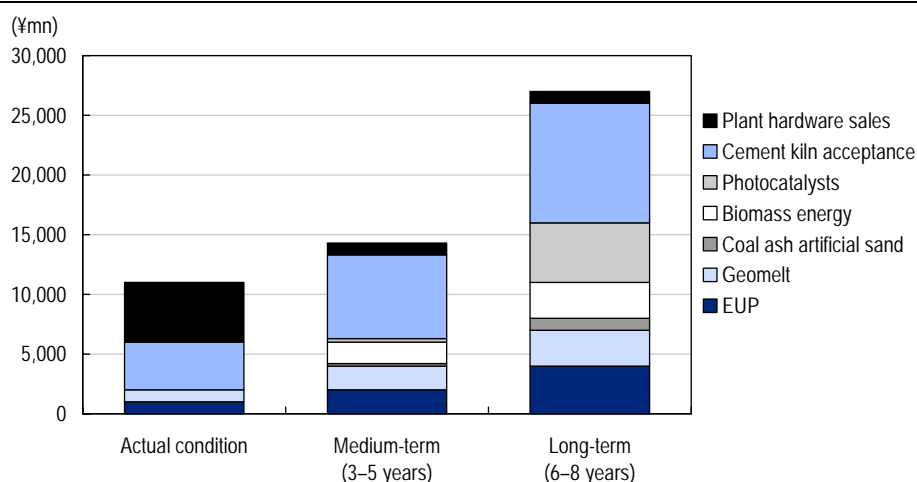
**Focus on Geomelt business**

In its environmental business, Ube is also stressing Geomelt. This is a solidification technology through which dioxins, PCBs, heavy metals, and other substances harmful to the soil are fused at high temperatures exceeding 1,600°C and rendered harmless. The technology also enables relatively easy on-site disposal. Ube is well versed in techniques of handling temperatures around 1,500°C in manufacturing cement and other products and possesses chemical technology for neutralizing harmful substances, so it is leveraging its expertise for business development.

**Development of biomass and other areas**

Ube is also involved in such other environmental businesses as biomass (recovering and processing wood waste, construction waste wood, and the like for use as energy sources) and commercialization of photocatalytic fiber (high-purity titania fibers that display oxide decomposition functions in organic matter when irradiated). The company intends to expand sales to more than ¥25bn (from over ¥10bn at present) over the coming 6–8 years. This increase should come from sales of these new businesses and cost savings in the cement business resulting from the waste from kilns being taken by biomass operations.

FIGURE 25. UBE INDUSTRIES' ENVIRONMENTAL BUSINESS



Source: Ube Industries.

## Chemical companies' biodegradable plastic measures

### Biodegradable plastics

*Firms have been working on biodegradable plastics since 1990, but cost is still a problem*

Plastic, the most representative petrochemical product, has a highly stable structure that makes its disposal after use an environmental problem. Recycling is costly, and there are many technical obstacles. Therefore, from around 1990, technological development has been proceeding apace with a view to polymerization of materials in nature and solving the disposal problem by biodegradation.

### Market to expand out from compost operations

Regional public organizations' compost processing is currently a field in which this technology is beginning to be used. Raw garbage is returned to the earth by burying it. Biodegradable plastic manufacturing methods can be divided as follows: chemical synthesis (petroleum and plant matter), high polymerization of starches and other natural materials, and materials produced by microorganisms.

### Showa Highpolymer leads in Japan

Figure 26 provides data on biodegradable plastics that have been used in finished products. Cargill Dow, which has an annual production capacity of 140,000 tons at its NatureWorks operations that dwarfs all others worldwide, has a tie-up with Mitsui Chemicals' Lacea, for which future expectations are generally high. Showa Highpolymer operates the first mass-production plant (3,000 tons/year at its Bionolle operations) in Japan, and this market is expected to expand gradually. We believe it has a slight lead over other chemical companies.

FIGURE 26. PRINCIPAL BIODEGRADABLE PLASTICS OF JAPANESE CHEMICAL MAKERS

Company	Products	Kinds	Major components	Notes
Showa Highpolymer	Bionolle	Synthetic polymer (petroleum base)	Polybutylenesuccinate Polybutylenesuccinate/adipate	
Mitsui Chemicals	Lacea	Synthetic polymer (organic)	Polylactic acid	Allied with Cargill, Dow
Cargill Japan	NatureWorks	Synthetic polymer (organic)	Polylactic acid	Partnering with Mitsui Chemicals US output at 140,000 tons/year
Nippon Shokubai	Lunare SE	Synthetic polymer (petroleum base)	Polyethylensuccinate/adipate	
Daicel Chemical Industries	Celgreen	Synthetic polymer (petroleum base)	Accetylcellulose Polycaprolactone	
Nippon Synthetic Chemical Industry	Mater-Bi	Natural polymer	Starch-PVA	Import/sales from Novamont (Italy)
MGC	lupec	Synthetic polymer (petroleum base)	Polybutylenesuccinate/carbonate	

Source: Company data, Nikko Citigroup Limited.

**Cost is an issue**

The low level of demand in such areas as compost will not support the mass production of biodegradable plastic. We believe other uses, such as packaging and sundries, must be found for full-scale mass production of biodegradable plastic to occur, but producers must overcome issues including high costs and problems in such areas as strength and durability. The domestic market scale is estimated to be only a small 20,000 tons/year at present. However, the Biodegradable Plastic Research Council estimates the market will grow to 100,000 tons/year in 2010. We anticipate a virtuous cycle, in which volume growth lowers manufacturing costs, which in turn generates new demand.

*Kiyotaka Teranishi*

## Environmental Responses in the Consumer Electronics Industry—Promoting Co-existence with the Global Environment

- We present below an analysis by Kiyotaka Teranishi of our consumer electronics team
- Our vision for longer-term growth in the consumer electronics industry focuses on establishing and sustaining decisive superiorities in digital audiovisual technologies and environmental technologies as core technologies
- The sector's first environmental moves have been in line with energy conservation and home appliance laws
- The second steps have been based on each firm's technological prowess, specifically the production of products that conserve energy and that meet environmentally responsible guidelines, while establishing environmentally conscious manufacturing infrastructure
- The third moves have been focused on new energies with lower CO<sub>2</sub> emissions, such as rechargeable batteries for electric vehicles, home solar power systems, and residential-use fuel-cell cogeneration
- We discuss the environment-related businesses of Matsushita Electric Industrial (MEI), Sharp, Mitsubishi Electric, and others

### Important role for the consumer electronics industry in home energy conservation

*Greater upside for energy conservation in homes rather than industry*

The consumer electronics industry primarily develops, manufactures, and sells home electronics equipment (audiovisual equipment and home appliances), a major durable consumption good category. Home power consumption was 243.6bn kWh in FY3/98, accounting for about 27% of Japan's total 913.2bn kWh in power consumption. This highlights the important role for the consumer electronics industry in home energy conservation.

According to the Agency for Natural Resources and Energy, Japan's final energy usage volume (converted to crude oil) in FY3/02 was 408mn kiloliters (kl) with a breakdown of 45.9% for industrial, 29.3% for individual/residential, and 24.8% for transportation sectors. The individual/residential group comes second after industrial usage. Furthermore, while final energy consumption by the industrial sector has remained largely flat with advances in energy conservation following experiences during the two oil crises in the 1970s, personal consumption has steadily risen with the growing proliferation and more advanced features and large sizes of air-conditioners, refrigerators, color TVs, video machines, PCs, and other equipment.

*Environmental technologies are critical to consumer electronics firms establishing sustainable competitive superiorities*

## Environment technology in the same category of core technology as digital capabilities

Medium- and long-term corporate visions presented by the consumer electronics industry seek to establish and sustain overwhelming competitive advantages in core areas of digital audiovisual and environmental technologies. These visions put environment technology in the same category of core technology as digital capabilities. We agree with the need to establish and sustain overwhelming competitive advantages with environment technology to achieve sustainable growth. A central theme of environment technology efforts is co-existence with the global environment.

MEI and Sanyo Electric have presented corporate visions calling for company-wide participation in promoting environmental support. Sharp has outlined a clean technology strategy for strengthening the LCD business to reduce power consumption. Pioneer, meanwhile, is strategically enhancing environmental support in its mainstay car stereo business to stay at the forefront of meeting environmental regulations in the European market.

We observe three main types of environmental support in the consumer electronics industry: 1) adherence to laws covering energy conservation, recycling home electronics equipment, and other areas; 2) technology development efforts (development of energy-conserving products, development of environment-friendly products, and establishment of production infrastructure taking into account environmental issues); and 3) support for new energies with low CO<sub>2</sub> emissions (home solar cell and home fuel-cell initiatives).

*MEI, which can afford R&D spending, leads peers in making products that meet conservation guidelines*

## Adherence to laws covering energy conservation, recycling home electronics equipment, and other areas

The first main type of support by the consumer electronics industry is adherence to laws covering energy conservation, recycling home electronics equipment, and other areas.

The revised Energy Conservation Law (Law Regarding Streamlining Energy Usage), which was promulgated in June 1998 and took effect from April 1999, addresses streamlined energy usage in a socioeconomic environment facing energy challenges at home and abroad. The government formulated this law amid calls for restrictions on usage volume of energies responsible for nearly 90% of CO<sub>2</sub> emissions and the need for concrete efforts to promote streamlined energy utilization against the backdrop of discussions at the Kyoto meeting on preventing global warming held in December 1997.

The top-runner approach adopted in this law seeks to promote improved energy consumption efficiency by electric equipment and other items. Specifically, it sets the threshold for electric equipment (home electronics and office automation equipment) energy conservation standards at the highest level of energy consumption efficiency currently available for each product category. This approach overtly targets reductions in CO<sub>2</sub> emission volume.

Under this system, authorities set deadlines for makers to achieve standard levels and inspect products from each maker for energy consumption efficiency in the target year to determine whether the target is met (authorities actually use energy consumption efficiency based on a weighted average of target equipment based on product shipment volume). This gives makers an incentive to release new products with excellent energy conservation features.

Equipment covered by the top-runner approach includes air-conditioners, fluorescent lights, TVs, video machines, electric refrigerators, electric freezers, copy machines, computers, magnetic disk devices, passenger cars (gasoline, diesel), cargo vehicles (gasoline, diesel), stoves (gas, oil), gas cooking equipment, gas and oil water heaters, bidet-equipped seats (warm water cleaner seats, heated seats), vending machines (cans, bottles), and transformers (for high-voltage power transmission).

Companies must have significant technology development capabilities to enhance energy consumption efficiency for individual products in line with the top-runner approach adopted in the revised Energy Conservation bill for the Japanese market. The gap is widening between makers capable of funding sufficient R&D outlays and those lacking adequate resources. We think this trend is particularly evident for home appliances, such as air-conditioners and refrigerators, with MEI widening its lead over other makers.

***The Home Appliances  
Recycling Law led  
companies to make  
recycling a business***

The Home Appliances Recycling Law (Designated Home Equipment Recycling Law), which was promulgated in June 1998 and took effect in April 2001, requires retailers, makers, and other related parties to promote proper disposal of products and effective utilization as resources by taking steps to facilitate the collection and recycling of used home electronics equipment. Japanese households throw away 600,000 tons of home electronics products annually with most going into landfills up to now. However, landfills have limits and cannot continue forever. Furthermore, equipment going into landfills contains many valuable resources that could be recycled. The government passed the Home Appliances Recycling Law to promote the recycling of valuable resources and reduce garbage volume.

The law designates four product categories—air-conditioners, TVs, refrigerators, and washing machines. Designation took into account 1) difficulty of recycling by municipalities, 2) whether a strong necessity exists for recycling, 3) whether designs and components have a significant impact on recycling, and 4) the ability of retail to manage collection as delivered products.

The law defines recycling as separation of parts and materials from used equipment and reuse of these parts and materials in products or as fuel.

Makers must recycle retrieved items to at least the standard level (recycling rate). These rates are more than 60% for air-conditioners, more than 55% for TVs, more than 50% for refrigerators, and more than 50% for washing machines. Makers also have an obligation to collect and either recycle or destroy refrigerant freon and replacement freon used in air-conditioners and refrigerators as part of the recycling process. Consumers pay a recycling fee of ¥3,500 for air-conditioners, ¥2,700 for TVs, ¥4,600 for refrigerators, and ¥2,400 for washing machines. They also cover collection and transport costs (set by retailers).

A recycling law passed in May 2000 calls for a 3R initiative (Reduce, Reuse, Recycle) as the basic approach to disposal and recycling. It also stresses proper processing of disposed items. Germany and some other countries have gone beyond the 3Rs and added Refuse (not buying unnecessary items) as a new concept. The Home Appliances Recycling Law is promoting 3R activity in Japan.

Since this law took effect, consumer electronics makers have established plants to conduct recycling of used home electronics products as well as R&D on recycling technology and are promoting recycling activities for used products. Industry leader MEI established the Matsushita Eco-Technology Center (Kato-gun, Hyogo Prefecture) and runs a recycling plant with a handling capacity of 200 tons per day. The center disassembles the four designated products (air-conditioners, TVs, refrigerators, and washing machines) and collects glass, steel, copper, aluminum, plastic, freon, urethane, and other items.

## Technology development support

The second type of environment support relies on technology development. Specifically, this includes development of energy-conserving products, development of environment-friendly products, and establishment of production infrastructure taking into account environmental issues.

***Developing  
environmentally  
responsible products  
using less power and  
fewer resources***

Companies develop energy-conserving products by reducing power consumption and limiting resource usage in daily R&D activities.

MEI is making substantial strides in these areas with new products (versus existing products from five years ago). We have listed some examples below.

1. Dishwashers reduce water volume by about 90% compared to washing by hand. This saves about ¥23,000 annually in water costs (around ¥25,400 by hand; ¥2,400 using MEI's dishwasher).
2. Drum-type washer-dryers reduce water volume by about 30% compared to existing products. This saves about ¥16,000 annually in water costs (around ¥56,000 with existing products; ¥40,000 using this product).
3. Non-freon refrigerators use a vacuum insulation material and non-freon compressor to reduce power consumption by nearly 85% compared to existing refrigerators. This saves about ¥23,000 annually in electricity costs (around ¥27,300 with existing products; ¥4,400 using this product; based on ¥23 = 1kWh).
4. Oxygen air-conditioners reduce power consumption by about 40% by using a high-efficiency scroll compressor. This saves about ¥16,000 annually in electricity costs (around ¥36,700 with existing products; ¥20,800 with this product; ¥23 = 1kWh).
5. Palook ball fluorescent lights reduce power consumption by about 76% compared to existing silica bulbs. This saves about ¥3,400 annually in electricity costs (around ¥4,500 with silica bulbs; ¥1,100 with Palook ball lights; ¥23 = 1kWh).

We think encouraging consumers with home appliances older than five years to upgrade to new models with newer technology is an important element of energy conservation in the home and cost savings should provide a valuable incentive.

According to a summary of electricity demand in FY3/03 from the Agency for Natural Resources and Energy, home electronics accounted for two-thirds of household power consumption with air-conditioners at 24%, refrigerators at 17%, lighting at 16%, and TVs at 10% (FY3/02 data).

Just as it is important for companies to develop energy-conserving products by reducing power consumption and limiting resource usage in daily R&D activities, we believe consumers should be more conscious of energy conservation with high-consumption equipment. Specific steps include 1) selecting equipment with high energy efficiency when upgrading, 2) setting heaters and coolers at reasonable temperatures, 3) reducing the frequency of opening and closing the refrigerator door, 4) keeping equipment switches off as much as possible, 5) unplugging equipment not being used, 6) checking for wasteful electricity spending, and 7) using substantial amounts of insulation and ensure a high level of airtightness when building new homes or making renovations.

### **Environment-friendly product development activities**

Some examples of environment-friendly product development activities are actively using non-freon compressors, lowering electricity consumption when equipment is on stand-by, eliminating parts and materials containing harmful chemical substances (at the design stage), and designing and manufacturing products that facilitate recycling.

MEI has been a leader in non-freon initiatives, such as substituting designated freon with replacement freon for product coolants in 1993 and replacing freon used to inflate insulation materials with other chemicals from 1994. The company expects to eliminate freon from all home refrigerators with 300 liters or more in capacity and have non-freon models account for 95% of home refrigerator shipped in Japan by end-December 2003.

Stand-by electricity consumption in Japanese households is an average 437kWh/year per household (which costs about ¥10,000/year per household), accounting for 9.7% of total household electricity consumption (4,487kWh/year per household). The breakdown of stand-by electricity consumption is 17% for video machines, 11% for component audio equipment, 11% for gas water heaters, 6% for satellite broadcast tuners, 6% for air-conditioners (heater/cooler models), 5% for phone-facsimile equipment, and 5% for TVs. While air-conditioners, refrigerators, lighting, and other home appliances contribute a substantial portion of electricity consumption in Japanese homes, video machines, component audio equipment, and other hi-fi audiovisual equipment dominates stand-by usage.

Makers are actively working to reduce stand-by electricity consumption through technological advances (similar to the previously mentioned efforts to reduce ordinary power consumption). The average stand-by electricity consumption of new video machines is one-fifth the level consumed by products from 10 years ago. Recent TVs and video machines have stand-by consumption of less than 1W, giving them excellent energy conservation credentials.

Besides efforts by consumer electronics makers to reduce stand-by power consumption in their regular development activities, we think it is also important for consumers to restrict consumption. Key steps are 1) regularly turning off equipment switches (it is possible to reduce stand-by electricity usage by about 25% by only turning on power switches when using equipment and leaving the switches off the rest of the time) and 2) unplugging equipment not in use (stand-by electricity usage can be reduced 43% by unplugging TVs and washing machines (as long as there is no impact on functionality from unplugging the power cord), when not being used).

### **Establishment of environment-friendly product infrastructure**

The establishment of environment-friendly product infrastructure includes using lead-free solder and implementing the “green plant” concept (strict removal of harmful substances from plants). Top consumer electronics companies are global leaders with environment measures.

### **Support for new energies with low CO<sub>2</sub> emissions**

The third type of environmental support by the consumer electronics industry is the development of new energies with low CO<sub>2</sub> emissions, such as electric car rechargeable batteries, home solar cell power generation systems, and home fuel-cell co-generation systems.

Involvement by consumer electronics makers in these areas include: 1) electric car rechargeable batteries: MEI (Panasonic EV Energy, a joint venture company with Toyota Motor, is at the forefront of volume production for hybrid electric vehicle [HEV] nickel hydrogen rechargeable batteries) and Sanyo (starting volume production of nickel hydrogen rechargeable batteries for Ford from end-2003) are leading, while Sony is working on the development of HEV lithium-ion rechargeable batteries; 2) home solar cell power generation systems: Sharp and Sanyo are top makers of these systems; and 3) home fuel-cell co-generation systems: MEI has a major lead in this business and is followed by Sanyo.

Home solar cell power generation systems are home generation systems based on solar cells. Advantages of the solar cell approach are 1) utilizing infinite solar energy resources (one hour of solar energy is equivalent to one year of global energy consumption; no worries about resource depletion), 2) no sound or CO<sub>2</sub> emissions during operation, 3) power generation at the source of demand (homes, etc.), and 4) no need for an energy transmission infrastructure.

METI offers subsidies to promote home solar cell power generation systems. The number of systems using the subsidies has steadily risen from 5,654 in 1997 to 6,532 in 1998, 15,879 in 1999, 20,877 in 2000, 25,151 in 2001, and 42,838 in 2002. The total budget in 2003 was about ¥10.5bn, or ¥90,000 per 1kWh. The Comprehensive Resources and Energy Survey Committee’s outlook for new energy usage targets 4.82mn kWh in installations by FY3/11.

*Development of fuel cells, solar cells, and rechargeable batteries for electric cars is progressing to reduce CO<sub>2</sub> emissions*



Sharp, the top maker of home solar cell power generation systems, sells a 4.6 kW system (4,518kWh in estimated annual output) for ¥2.86mn, a 3.21 kW model (3,192kWh) for ¥1.98mn, and a 1.8 kW model (1,865kWh) for ¥1.03mn. These are obviously expensive purchases. By establishing connections to the power company, households can sell excess power (beyond current needs) when solar power generation efficiency is high during the daytime hours and purchase electricity from the power company for nighttime requirements and on rainy days with low output.

The key device in these systems is solar cells. Global production volume in 2001 rose 37% to 394MW (versus 201MW in 1999 and 288MW in 2000) with Japan up 43% to 171MW (versus 80MW and 129MW), the US up 40% to 105MW (versus 61MW and 75MW), and Europe gaining 42% to 86MW (versus 40MW and 61MW). Production shares for solar cell makers in 2001 were 19.0% for Sharp, 14.7% for BP Solarex, 13.7% for Kyocera, 9.9% for Siemens, 6.6% for AstroPower, and 4.8% for Sanyo.

Home fuel-cell co-generation systems insert air and hydrogen (obtained in the home by passing city gas or LP gas through a fuel processor) into a solid-state, polymer fuel cell and use reverse electrolysis to generate electricity and hot water. These systems, which require joint development with gas companies to extract hydrogen in the home, provide simultaneous generation of electricity and hot water.

Japan started R&D work on co-generation systems as a national project from 1996, and Tokyo Gas and Osaka Gas plan to launch products from March 2005 and March 2006, respectively. Tokyo Gas has already selected MEI and Ebara Ballard to supply related equipment. Osaka Gas has four candidates (MEI, Sanyo, Ebara Ballard, and Toshiba) and intends to select final suppliers in March 2004.

The government plan anticipates co-generation system installations reaching 2.1mn kW by FY3/11 and 10mn kW by FY3/21. Although the projected market size of ¥300bn by around FY3/11 is not very large, MEI and Sanyo are promoting commercialization as company-wide projects with expectations for full-fledged expansion in another decade.

The anticipated manufacturing cost for a co-generation system when market launch begins in FY3/06 is about ¥1mn, and we expect METI to subsidize the difference between this cost and the likely market price (roughly ¥500,000) along the lines of solar cell assistance. While this price is more expensive than existing home gas heaters (¥200,000–¥300,000), the co-generation system also supplies electricity and can therefore cover the difference in about five years through electricity bill savings. We believe co-generation systems will offer consumers sufficient benefits despite higher initial costs given their projected useful life of at least 10 years.

**Yoshihiko Yamamoto**

## Pharmaceutical and Medical Device Industries and the Environment

- We present below an analysis by Yoshihiko Yamamoto, one of our pharmaceutical team analysts
- Japanese corporations, which had caused numerous tragic pollution problems in the past, began to gradually acknowledge the importance of environmental issues with the revelation in 1963 that pollution was the cause of Minamata disease. Corporate management has subsequently undergone a major shift, particularly since the mid-1990s, toward emphasizing environmental contributions. As of July 2003, there were 12,392 ISO14001-accredited Japanese companies, a considerably higher number than the 3,032 companies in the US
- That said, we still see many major corporations that neglect these principles in their day-to-day operations, and we are thus unable to highly regard those companies at which executives' remarks and environmental reports are essentially superficial and do not represent a genuine management approach focused on environmental issues
- Physical production volumes in the pharmaceutical industry are much smaller than in other manufacturing industries, and industry-wide energy consumption and CO<sub>2</sub> emissions amount to only around one-quarter to one-third those of major petrochemical companies. However, pharmaceutical companies could release unknown harmful substances into the environment, including genes, proteins, and other biological products, and the industry must also consider animal welfare issues in its animal experimentation. We therefore believe that the pharmaceutical industry needs to be evaluated under different systems than those used for other manufacturing industries
- The Japanese pharmaceutical industry is working to address environmental issues, mainly through the Japanese Pharmaceutical Manufacturers Association (JPMA), which has 80 member companies. The JPMA has published an annual environmental report since 1999, and 57% of members companies had published individual reports as of FY3/03. However, these reports did not address such issues as unknown harmful substances, animal welfare, and medical malpractice, and we think the industry needs to make improvements in these areas
- One issue for the medical device industry is raw material PVC. PVC incineration in Japan, where the widespread use of high-temperature incinerators lags Europe, entails a high risk of dioxin generation. The properties of PVC make it an indispensable raw material in blood bags and other medical devices, and there are some applications for which it would be difficult to switch PVC for other raw materials. We think the Japanese industry should resolve this issue by adopting incineration methods along the lines of those in Europe

- **Other problems facing the medical device industry include medical waste and medical malpractice. It is difficult for individual companies and industries to resolve such issues, so we think collaboration with medical institutions and the government, including local authorities, is necessary. Terumo's management approach represents, in our view, an example of steps to resolve medical industry environmental issues**
- **Although environmental management appraisal organizations are increasing in number, we are yet to see the development of superior evaluation systems. We plan to use the following survey as a starting point from which we conduct further research to be able to provide investors with advice regarding the evaluation of companies' environmental business practices and investment**

### *Pharmaceutical industry environmental issues*

## Introduction

Almost 20 years has passed since the book *Ethical Investing* was published in 1984 by US author Ami Domini, during which time there has been an increasing emphasis on investment in companies engaged in sustainable business activities. Essential factors underpinning sustainability include ethical corporate activities and social responsibility, as well as compliance with the law. With human activity continuing to destroy the environment, an important challenge is for corporations to act in a more socially responsible manner to leave the environment in a better state than it is today.

Most discussions concerning the social responsibilities of the pharmaceutical industry have been from the perspective of the damage caused by drug side effects. In fact, we, as securities analysts, also incorporated discussions of corporate responsibility from the perspective of drug side effects and medical accidents into our investment recommendations. This is because we had the preconception that the pharmaceutical industry had little impact on the environment because, compared with other manufacturing industries, it produces substantially less product, in terms of both mass and volume.

The claims in the UNEP Finance Initiative prompted us to begin considering the environmental issues associated with the pharmaceutical industry. Here, we provide a summary of our preliminary research into this issue.

### *Rising number of ISO14001-accredited companies*

## Japanese corporate attitudes

After WWII, Japan prioritized economic growth so that its population would not starve as the country emerged from its postwar ruin, but this led to continued environmental degradation and numerous pollution problems. Corporate activities threatened the very existence of the Japanese people. Urban waterways were polluted and foul-smelling, and there was a high incidence of respiratory disease among the inhabitants of Kawasaki, Yokkaichi, and other industrial zones, due to atmospheric pollution. The importance of environmental issues was only recognized nearly 20 years after the war had ended. In 1963, it was announced that factory wastewater had caused Minamata disease. This tragic incident prompted local residents to play a stronger role in monitoring corporate activities and companies then began to progressively address environmental problems.

Currently, the government is still promoting policies with negative consequences for the environment in the name of public investment. However, since the mid-1990s, there has been a major change in private-sector attitudes toward environmental issues. As of July 2003,

12,392 Japanese companies had obtained ISO14001 accreditation (by the International Organization for Standardization that regulates environmental standards), which is significantly higher than the figure of 3,820 companies in Germany and 3,032 companies in the US with this certification. These figures demonstrate, in our view, that Japanese companies are serious about environmental issues. We attribute the lack of ISO-accredited companies in the US, which has a much larger economy than Japan, to the same attitude toward the environment that has resulted in the US government not ratifying the Kyoto protocol.

Many listed Japanese companies are now moving from a passive approach, founded on environmental preservation, to making a more proactive contribution toward the environment. These companies issue annual environmental reports and are implementing environmental measures based on more stringent targets than those required under the ISO criteria. On a global and regional basis, we feel local inhabitants now see Japanese companies as taking a lead in improving the environment, rather than as the enemy. We believe regional environmental damage is more likely to be caused by a minority of selfish local residents than by Japanese corporations.

**Numerous instances of environmental damage and near-miss accidents due to neglect in day-to-day operations**

### Evaluating environmentally friendly business practices

However, not all Japanese companies are proactively putting environmentally friendly measures in place. There has been a series of accidents that have damaged, or nearly damaged, the environment over the past two years alone, including the nuclear power plant accident at Tokyo Electric Power Company (TEPCO), the blast furnace explosion at Nippon Steel, the factory fire at Bridgestone, the oil refinery fire at Idemitsu Kosan, inadequate line engineering works by JR East, and the failed launch of the H2 rocket by NASDA. The common cause of all these accidents was neglect in day-to-day operations. The artisan spirit emphasizing day-to-day operations on the shop floor that underpinned Japan's manufacturing industries is now considered old hat, likely, we believe, because management methods increasingly focus on financial statement figures over anything else.

We doubt, however, that all such businesses have been neglectful vis-à-vis environmental issues. At the very least, most are still issuing environmental reports, and executives are stressing the importance of their environmental policies. That said, we cannot rely solely on company announcements, as they do not provide a good assessment of a company's attitude. We think analysts should look beyond the aspirations of corporate executives and evaluate companies on the basis of actual business outcomes, although this is extremely hard to do. We face the same problem when assessing corporate governance. Japan is also introducing Western-style systems of corporate governance, and there is a tendency to assess corporate governance solely on the basis of such systems. In practice, however, firms that have adopted such Western systems do not necessarily have better corporate governance. In our view, some companies still using traditional Japanese management styles have better corporate governance. We believe the main problem is the executive mindset.

**Total pharma industry energy consumption and CO<sub>2</sub> emissions only around one-fourth to one-third that of major petrochemical companies**

### Pharmaceutical industry characteristics

When looking at environmental issues, it is important to keep in mind that the pharmaceutical industry differs from other manufacturing industries in a number of ways. First, there is a substantial difference in production volumes. Industries, such as steel or chemicals, manufacture and sell products by the tonne, whereas production volumes in the pharmaceutical industry are at most one-thousandth or even one-millionth of this, in units of kilograms or grams.

As a result, the pharmaceutical industry uses much less energy for production and distribution, and emits much less CO<sub>2</sub>. For example, in FY3/02, 69 JPMA member companies used 1.07mn kL of energy (crude oil equivalent) and emitted 2.14 tonnes of CO<sub>2</sub>, whereas chemicals major Mitsubishi Chemical used 3.13mn kL of energy and emitted 8.4mn tonnes of CO<sub>2</sub>.

As the 69 JPMA member companies account for 90% of Japanese pharmaceutical production value, energy consumption and CO<sub>2</sub> emissions by the pharmaceutical industry amount to only around one-fourth to one-third that of major petrochemical companies. That is, the pharmaceutical industry makes a minimal contribution to global warming. Of course, we are not saying that pharmaceutical manufacturers do not need to make efforts to reduce energy consumption and CO<sub>2</sub> emissions.

**High degree of supervision required of management given that pharmaceutical companies are suppliers of harmful substances**

Second, pharmaceutical products are chemical substances with high-level biological activity. As a result, the manufacture and sale of pharmaceuticals is strictly regulated by the authorities in each country, and their use is entrusted to highly trained physicians. Drug side effects should not be viewed as an environmental issue and should not call into question the company's responsibility, other than where the company has not complied with ethical principles or legal procedures during product manufacture and sale or during the clinical trials performed to obtain manufacturing authorization.

However, as suppliers of harmful substances, pharmaceutical companies should pay particularly close attention to the following issues:

- Packaging that prevents individuals other than the patient from mistakenly taking the drug
- Prevention of environmental pollution from the incorrect disposal of unused drugs
- Prevention of environmental pollution after the consumed drug has been excreted from the body

In addition to there being no legal regulations in place covering such issues, the environmental policies being promoted by pharmaceutical industry bodies do not even recognize these as problems. Therefore, as well as closely monitoring future moves by the various companies, industry bodies, and regulatory authorities, we think investors should also make their opinion heard on these issues.

Third, pharmaceutical research can generate unknown harmful substances that could be released into the environment. Such substances include microorganisms, genes, and proteins created using biological techniques, as well as novel chemical entities (NCEs) created by chemical synthesis. As such potentially harmful substances are completely new, it is impossible to predict how dangerous they may be. Pharmaceutical companies must follow Good Laboratory Practice guidelines put into place by the regulatory authorities to govern such research, and are also expected to establish high-level supervision and management structures, such as education on researcher awareness or facility design and management, to protect researcher safety and prevent such substances from escaping into the external environment.

**Also critical to address animal welfare and medical malpractice issues**

Fourth, the pharmaceutical industry has to perform experiments on humans and animals as part of their research. Ethical concerns must be taken into account, both for human clinical trials and to prevent unnecessary animal experiments because of animal welfare issues. In addition, management must consult with regulatory authorities around the world, and efforts must be made to reduce the level of unnecessary animal experimentation.

Finally, there is the issue of product-related medical malpractice. A physician's prescription is required when using a drug, with the exception of over-the-counter (OTC) medications. In

other words, pharmaceutical companies are not thought to be accountable for drug misuse. That said, we believe they should work toward reducing the number of malpractice cases arising from drug misuse. Pharmaceutical companies could, for example, contribute by developing packaging that is difficult to mishandle, preparing easy-to-understand explanation inserts, and avoiding the use of easily mistaken drug names. Management should, in our view, focus on reducing the incidence of medical malpractice from a product-design perspective.

*Companies should recognize the issues of unknown chemical substances, animal welfare, and medical malpractice as environmental problems*

## Efforts by Japanese pharmaceutical companies

The JPMA is proactively involved in guiding Japanese pharmaceutical companies to address environmental issues. The JPMA currently has 80 member companies, including non-Japanese firms. The organization established its corporate charter in 1997 and is working to facilitate better corporate ethics and compliance with laws and ordinances. The JPMA has highlighted environmental issues as a key challenge and, since 1999, has published an annual pharmaceutical industry environmental report.

Currently, the JPMA is working on the following environmental issues.

### Energy conservation and prevention of global warming

To reduce CO<sub>2</sub> emissions to the 1990 level of 1.66mn tonnes by FY3/11, in line with the Kyoto Protocol ratified by the Japanese government on June 4, 2002.

### Management of chemical substances

Of the 353 Class I chemicals, to reduce, by FY3/04, the amount of dichloromethane, 1-, 2-dichloroethane, and chloroform emitted into the atmosphere by 60%, 50%, and 30%, respectively, vis-à-vis FY3/96 emission levels. A separate plan is to be formulated vis-à-vis controlling emissions for other chemicals.

### Resource conservation and waste

To reduce the amount of waste for disposal to 30% of the FY3/91 level by FY3/11. By FY3/02, the industry had already reduced waste levels to 25.5% of the FY3/91 level.

### Environmental management

JPMA is supporting member companies in obtaining ISO14001 accreditation and in the development of an Occupational Safety & Health Management System (OSHM). It is also urging members to publish environmental reports (in FY3/03, 57% of members issued such reports).

### Research and education

The JPMA is running and promoting environmental accounting study groups and other activities for member companies. The organization holds research meetings on environmental issues to raise awareness among members. Moreover, the JPMA and member companies regularly visit regulatory authorities and major pharmaceutical firms in Europe and the US to investigate how western countries address environmental issues.

We can evaluate the efforts and results of specific strategies implemented by Japanese pharmaceutical companies in addressing environmental issues—such as energy conservation or measures to conserve resources and reduce waste—from environmental reports issued by the JPMA and the companies themselves. However, some issues unique to the pharmaceutical industry, including management of unknown chemicals, animal welfare, and medical malpractice, are not yet widely acknowledged as being environmental issues. We think that both the industry as a whole and individual companies will need to address these matters urgently and to investigate ways in which they can respond to these important challenges.

***High-temperature incinerators that do not generate dioxins should be used more to resolve PVC disposal problem***

## Medical device industry

Unlike pharmaceuticals, the manufacture of sophisticated medical devices, such as dialysis equipment, catheters, and such general-purpose medical equipment as syringes, requires substantial amounts of raw materials and energy. Moreover, after these products have been used, they become hospital waste that is difficult to dispose of. Investors thus need to understand that medical devices differ from pharmaceuticals in terms of their environmental impact.

We think the biggest problem for the medical device industry is the use of plastic raw materials, especially PVC that produces dioxin when incinerated at low temperatures. Japanese local authorities are working to install high-temperature incinerators that function above 800°C to prevent dioxin production, but many low-temperature incinerators are still in operation. The situation is completely different in Europe, where almost all incinerators have been converted to high-temperature models. Another problem with PVC is that, when used in transfusion bags, the PVC absorbs the drug contents. Further, diethyl hexyl phthalic acid (DEHP), which is used as a plasticizer in PVC, is known to mimic the action of sex hormones.

PVC thus causes various problems when used in medical materials. However, there is no substitute for PVC in terms of its physical, mechanical, and economic properties. For example, PVC used in blood transfusion bags allows gas exchange (whereby O<sub>2</sub> and CO<sub>2</sub> are exchanged) to facilitate cell respiration, while the DEHP plasticizer protects red blood cell membranes. Blood bags made of polybutadiene, which is considered the closest material to PVC, are of no practical use as hemolysis occurs within a short period of time. By law, many medical devices must be sterilized by autoclave, but no plastics other than PVC combine resistance to these high temperatures for the necessary periods of time with elasticity at low temperatures and cost effectiveness.

## Case study: Terumo

***Terumo actively working to resolve environmental issues by substituting certain raw materials***

The medical device industry is facing a number of technological problems. Below we provide a case study on how Terumo, Japan's largest medical device manufacturer, is addressing environmental issues.

Terumo established environmental management offices at its plants in 1972 and has strived ever since to address environmental issues. The company has worked on the obvious targets of energy conservation, reduced CO<sub>2</sub> emissions, and improved chemical handling, but it has also tackled the major obstacle of changing the materials used in its products. As a result, Terumo has focused on the following challenges in its product development:

- No use of harmful chemical elements (e.g., mercury)
- No use of halogenated materials, such as PVC
- No use of highly leachable plasticizers, such as DEHP
- Reduction in composite materials, such as plastics and metals
- Reduction in the volume and weight of waste materials

This concept for product development has generated a number of results. In 1980, Terumo replaced rubber with thermoplastic elastomer in its syringe gaskets, thereby preventing the production of sulfur oxide on incineration. In 1981, the company started using ethylene vinyl acetate (EVA) copolymer in its transfusion containers, so harmful gases would not be produced on incineration. In 1984, Terumo halted all production of mercury thermometers (the company's first ever product) and made a complete switch to digital thermometers. The company switched from mercury to digital blood pressure gauges in 1992 for the same reason.

The company saw the first results from its efforts to substitute PVC raw materials emerge in 1991, when it launched a transfusion set that used polybutadiene tubes (the first Terumo product in which PVC had been replaced). Then in 1999, Terumo launched a peritoneal dialysis bag that used polypropylene instead of PVC and also reduced waste weight by 40%. The plasticizer DEHP is particularly problematic when used in pediatric products, as it is a highly leachable environmental hormone. To solve this problem, Terumo began using trioctyl trimellitate (TOTM) as a low-leaching plasticizer. The company launched pediatric transfusion sets using TOTM in November 2002. However, PVC is superior to other materials in many ways and for many applications it is very difficult to identify suitable replacement materials. Thus, appropriate disposal methods for waste materials are extremely important.

When disposing of or recycling medical equipment, most equipment must be treated as waste after it has come into contact with patients' blood. Recycling is therefore associated with substantial risks. Medical waste disposal is entrusted to the medical institutions, but medical device manufacturers cannot completely avoid responsibility for this issue. Terumo introduces medical institutions across the country to highly reliable waste disposal operators and periodically audits the operations of these operators.

Another headache for medical device manufacturers is accidents by healthcare practitioners when using medical devices and equipment. Some accidents are caused by inadequate expertise and experience on the part of the healthcare practitioner, while others are caused by the use of old equipment that has exceeded its service life. Medical equipment should be subjected to the same tests and licensing procedures as used with cars. Ideally, equipment performance should be rechecked on a regular basis, while equipment vendors should be licensed. This issue is one that we feel needs to be addressed at a government level, and is not something a single company can manage alone. Terumo has made continued efforts to provide training at nursing schools for sophisticated medical equipment and to switch from equipment sale to rental so that new equipment is always available in the clinical setting.

**Evaluation system  
needed to be able to  
appraise companies'  
environmental issues**

### Individual company evaluation and share price impact

There are over 100 ratings agencies globally that evaluate environmentally friendly business practices, but the criteria underpinning such ratings are unclear and the agencies are not yet that influential. For example, on December 11, 2003, the *Nikkei Sangyo Shimbun* published a ranking of companies based on the degree of environmental friendliness of their business practices. The newspaper conducted a questionnaire survey covering the six categories of operational structures/environmental education, policies on global warming and distribution, product strategies, resource recycling, pollution risks, and corporate vision. The newspaper rated the responses and ranked manufacturers and non-manufacturers separately. Other agencies' evaluation systems are not publicly available.

As we have already discussed, each industry has its own idiosyncrasies, and it is extremely difficult to accurately evaluate a company's efforts vis-à-vis the environment on the basis of company comments, publications, and systems alone. We thus do not recommend investors making investment decisions simply on the basis of these rankings as proxies for evaluating how each company is addressing environmental issues. We provide, for reference, an example of such a ranking in Figure 27.



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**FIGURE 27. NIKKEI SANGYO SHIMBUN RANKING OF GREEN BUSINESS PRACTICES AT PHARMACEUTICAL AND MEDICAL DEVICE MANUFACTURERS**


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Rank	Company Name	Rank	Company Name
37	Fujisawa Pharmaceutical	276	Otsuka Pharmaceutical
53	Kyowa Hakko Kogyo	283	Tsumura & Co.
139	Yamanouchi Pharmaceutical	302	Taisho Pharmaceutical
150	Terumo	309	Takeda Chemical Industries
157	Shionogi	318	Kissei Pharmaceutical
165	Daiichi Pharmaceutical	368	Kaken Pharmaceutical
171	Chugai Pharmaceutical	373	Kyorin Pharmaceutical
181	Eisai	375	Toyama Chemical
212	Mitsubishi Pharma	385	Mochida Pharmaceutical
233	SSP	398	Torii Pharmaceutical
240	Tanabe Seiyaku	445	Morishita Jintan
247	Sankyo	508	Hisamitsu Pharmaceutical
259	Santen Pharmaceutical	533	Mikasa Seiyaku
272	Dainippon Pharmaceutical	580	Medical & Biological Laboratories

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Source: December 11, 2003 Nihon Keizai Shimbun, 7th Survey on Environmentally Friendly Business Practices.

Although we are well aware that environmentally friendly business practices will have a significant impact on a company's continued existence, we have not attempted an in-depth investigation into the efforts being made at each company. As a conclusion to this report, we have simply conducted interviews at the JPMA and at Takeda Chemical Industries, Yamanouchi Pharmaceutical, Taisho Pharmaceutical, and Terumo and investigated the environmental reports issued by the major pharmaceutical players. Therefore, we cannot make investment recommendations on the basis of these investigations. We will work to build an evaluation system to further our investigations.

## Investment theses, valuations, and risks

### Toyota Motor

#### Investment thesis

We rate the shares of Toyota Motor Buy/Medium Risk (1M), with a ¥4,350 target price. Not only do we consider Toyota highly cost-competitive in established areas, we believe it also has an overwhelming lead over competitors in commercializing new technologies, such as hybrid cars and the G-Book (telematics). The company's expansion of its global production network in Europe, North America, Asia, and elsewhere is beginning to produce results, and we anticipate considerable earnings contributions in the coming years.

In Japan, too, with the introduction of the Lexus brand, the reorganization of the five-channel sales system, and other initiatives, Toyota is pressing ahead with restructuring measures while maintaining high earnings. We expect negative supply/demand factors, such as the unwinding of cross-shareholdings, to improve from H2. If Toyota succeeds with its medium-term growth strategy, we believe it may well become the top global automaker, and we reiterate our Buy stance.

#### Valuation

We basically use PCFRs to value companies in the auto sector. We employ a five-tier PCFR model, based on US GAAP data for FY3/00–FY3/03, and use industry trends, earnings trends, and intra-sector comparisons in calculating our target prices. The five tiers are 1) the absolute high PCFR, 2) the average high PCFR, 3) the average of the low and the high PCFR, 4) the average low PCFR, and 5) the absolute low PCFR. We use the average low PCFR (about 7.5x) to set our target price for Toyota.

We use a low multiple for the following reasons: 1) concerns regarding the potential impact of further yen appreciation have yet to be assuaged, and 2) intensifying competition and trade friction are starting to become issues that could affect the company's currently strong US auto sales. Applying a multiple of about 7.5x to our FY3/04 CFPS estimate of ¥576.6 (US GAAP basis) gives us our target price of ¥4,350. Our target price equates to a prospective FY3/04 PER of 15x (lower than the average low of the past four years), a PBR of around 1.9x (below the average of the highs and the lows of the past four years), and an EV/EBITDA of 8.7x, (also below the average of the highs and the lows of the past four years).

#### Risks

We believe the major risks facing the auto sector include: 1) forex trends, 2) domestic sales trends, and 3) US sales trends. We believe risks to our target price for Toyota include the following: 1) the yen appreciating beyond ¥100/US\$1, 2) greater-than-expected demand declines and fiercer competition in North America, and 3) a protracted slump in domestic sales.

The impact on OP of Toyota's exposure to forex fluctuations vis-à-vis the US dollar has increased—to nearly ¥25bn for every ¥1 change in the yen/US dollar rate—in line with the expansion of its North American operations, but the company is offsetting this impact by boosting profits through cost reductions and sales growth. However, Toyota is also incurring greater costs in North America on the ramping up to production of new models and on higher incentive spending, and we will be keeping a close watch on trends in these costs. In the domestic market, although Toyota is growing its share of the recreational vehicles (SUVs, minivans, and station wagons) segment, we are cautious on the possibility of declines in sales of models that have been on the market for over a year, particularly for compacts and sedans. If these factors manifest themselves differently than we have anticipated, earnings may differ from our forecasts, and the share price may vary from our target price.

We rate the shares Medium Risk (M) based on their three-year historical volatility, which places them in the sixth through ninth deciles in terms of share price risk compared with our coverage universe.

## Honda Motor

### Investment thesis

We rate the shares of Honda Motor Hold/Medium Risk (2M), with a ¥4,650 share price. The key point with Honda, in our view, is North American auto sales, which effectively contribute nearly 80% of overall earnings. In particular, we think there it likely that earnings growth will stall as Honda finds itself unable to further expand North American production of light trucks—a major earnings driver—in H2, because its factories there are already operating at full capacity. Honda continues to see substantial YoY declines in domestic sales, and the effect on earnings of the release of the remodeled Odyssey remains unclear. That forex and other risk factors are expanding also merits close observation, in our view. The shares have weakened owing to the expected deterioration in earnings, but we maintain our cautious investment stance on them.

### Valuation

We basically use PCFRs to value companies in the auto sector. We employ a five-tier PCFR model, based on data for FY3/00–FY3/03, and use industry trends, earnings trends, and intra-sector comparisons in calculating our target prices. The five tiers are 1) the absolute high PCFR, 2) the average high PCFR, 3) the average of the low and the high PCFR, 4) the average low PCFR, and 5) the absolute low PCFR.

We use the average low PCFR to reflect the potential share price impact of 1) yen strength, 2) a slump in North American earnings, 3) lackluster growth in domestic sales volumes, and 4) a slowdown in earnings growth rates. Our ¥4,650 target price is derived from the average low PCFR of about 7x and our FY3/04 CFPS estimate of ¥690.7. Based on our FY3/04 estimates, our target price equates to a PER of 9.7x (slightly below the average of the lows over the past four years), a PBR of 1.5x (in line with the average of the lows over the past four years), and an EV/EBITDA multiple of 6.5x (in line with the average of highs and lows over the past four years).

### Risks

We believe risks facing the auto sector include the following: 1) forex trends, 2) domestic sales trends, and 3) US sales trends. We believe risks to our target price for Honda include the following: 1) yen appreciation beyond ¥105/US\$1; 2) further declines in domestic unit sales; and 3) a sharp increase in US demand or further growth in incentives. If these factors manifest themselves differently than we have anticipated, earnings may differ from our forecasts, and the share price may vary from our target price.

We rate the shares Medium Risk (M) based on their three-year historical volatility, which places them in the sixth through ninth deciles in terms of share price risk compared with our coverage universe.

## Mitsubishi Corp.

### Investment thesis

We rate the shares of Mitsubishi Corp. Buy/Medium Risk (1M), with a target price of ¥1,240. Earnings at trading companies are moving into a new stage from a focus on downsizing or consolidating unprofitable businesses to one emphasizing growth strategies for core businesses. We feel Mitsubishi Corp. maintains a substantial lead over peers on this front. In addition to strong performances in key business areas (LNG, foods, and coking coal), we expect a sharp recovery at its Southeast Asian autos projects to support record NP of about ¥100bn in FY3/04, and double-digit RoE. Mitsubishi Corp.'s shares have risen to around the PBR-based theoretical value that has served as our target price, but we think that if the company can clearly demonstrate continuing earnings growth at the NP level in the near future, the shares could rise further toward the theoretical fair value indicated by our PER-based calculations.

### Valuation

We reference PER and PBR multiples in setting our target prices for trading companies, selecting the method that generates the lower theoretical share price. For PER, we use the

market average. TOPIX is trading at an average PER of 21x based on FY3/04 forecasts, according to *Nikkei* data. For PBR, we apply what we believe is a fair value relative PBR multiple to the market average PBR. Since October 1994, Mitsubishi Corp.'s weighted average PBR range relative to TOPIX is 0.47x–0.97x (historical average of 0.76x). We feel that using a relative PBR of 1.1x, above the high end of its historical range, is reasonable. We set our target price for Mitsubishi Corp. using a PBR of 1.82x, the product of the TOPIX average PBR of 1.65x and our relative PBR of 1.1x. Our 21x fair value PER applied to our FY3/04 EPS forecast of ¥59.1 yields a theoretical share price of ¥1,240; a PBR of 1.82x applied to our end-September 2003 BPS of ¥694 yields a theoretical value of ¥1,260. We take the lower of these two figures and set our target price at ¥1,240.

**Risks** Risks to our target price include 1) economic erosion in Japan or overseas varying from the forecasts of our EMA team; 2) substantial changes in the price of oil, copper, or other commodities, impacting earnings from the company's core energy business; and 3) changes in BPS prompted by fluctuations in earnings from overseas operations (as a result of forex trends) or changes in the foreign currency translation account. If these factors manifest themselves differently than we have anticipated, the share price may not reach our target price.

We rate the shares Medium Risk (M) based on their three-year historical volatility, which places them in the sixth through ninth deciles in terms of share price risk compared with our coverage universe.

### Tokyo Gas

#### Investment thesis

We rate the shares of Tokyo Gas Buy/Low Risk (1L), with a ¥533 target price. We think strong results at core operations will allow the company to reward both consumers (with rate cuts) and shareholders (by increasing its dividend from ¥6 to ¥7 or so). We think Tokyo Gas is on track to achieve most of its targets ahead of schedule in FY3/05, which represents the third year of its second medium-term business plan, and that the resources for shareholder returns are likely to increase under the next medium-term plan. At this stage, we believe the market is incorporating the next dividend increase (to ¥8) into the share price.

While we have switched to a dividend discount model in our valuation for Tokyo Gas, we still believe the DCF model we used previously is the most appropriate metric for the valuation of the company's core operations. That said, even if the scope of liberalization is increased in FY3/06, we expect deregulation in the gas industry to be limited to less than 20% of sales versus 50% for the electric power industry. We think it will be difficult to set valuations based on earnings and potential cash flow growth for the next year or so.

Our DCF model generates a theoretical share price of ¥620. Considering the company's policy for shareholder returns (linking more than 70% of FCF to returns) and the clear basis for calculating FCF allocated for returns to shareholders, we think the shares will move to this level. Our DCF assumptions include WACC of 6.3%, a market-risk premium of 6%, a risk-free rate of 2%, and a beta of 1. (The historical and implied beta values for the stock are both 0.4, but we take a conservative approach and apply a beta of 1.0.) We assume an 8.5% cost of equity and a 2.2% after-tax cost of debt in our WACC calculation.

**Valuation** Our theoretical share price based on our dividend discount model is ¥533, using a discount rate of 1.5% (long-term interest rate plus risk premium). Our long-term rate of 1.4% is our EMA team's estimate for the JCB yield one year out, and our risk premium is the lower end of the spread (0.1%) versus the JGB yield since the market was first deregulated (November 1999).

**Risks** Target price risks include the following: 1) growth in FCF, which would enable the company to pay a dividend of ¥8, may be unsustainable; 2) expectations for inflation could emerge; and

3) investors could shift out of the stock due to robust earnings in export and other industries. Regarding the first point, management would need regulatory approval to increase rates if profits decline, meaning that falling earnings would seriously dent dividends and other return for investors. Specifically, we would expect plunging returns if sales volume growth fell below 3% (the level at which higher sales can no longer negate price reductions and sustain earnings growth, in our view). In this case, we would value the shares using the dividend discount model we use for gas and power companies, which would merit dividends of only ¥5 or ¥6.

We rate the shares Low Risk (L) based on their three-year historical volatility, which places them in the lowest decile in terms of share price risk compared with our coverage universe.

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**COMPANIES MENTIONED IN THIS REPORT**


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Company	Code	Rating	Share price (2/12/04)
JGC	1963	NR	¥1,000
Showa Denko	4004	2H	¥216
Mitsubishi Gas Chemical	4182	1H	¥351
Mitsui Chemicals	4183	2H	¥582
Ube Industries	4208	3H	¥167
Showa Highpolymer	4214	NR	¥282
Takeda Chemical Industries	4502	1M	¥4,530
Yamanouchi Pharmaceutical	4503	1M	¥3,490
Taisho Pharmaceutical	4535	2M	¥1,915
Terumo	4543	1M	¥2,260
Chiyoda Corp	6366	NR	¥645
Toshiba	6502	1H	¥434
Matsushita Electric Industrial	6752	1M	¥1,515
Sharp	6753	2H	¥1,750
Sony	6758	2H	¥4,350
Sanyo Electric	6764	2H	¥535
Pioneer	6773	1H	¥3,080
Kyocera	6971	3H	¥7,430
Mitsubishi Heavy Industries	7011	NR	¥304
Toyota Motor	7203	1M	¥3,490
Honda Motor	7267	2M	¥4,500
Mitsubishi Corp	8058	1M	¥995
Tokyo Gas	9531	1L	¥412
Osaka Gas	9532	2L	¥312
AstroPower	APWR	NR	US\$0.08
Siemens	SIEGn.DE	2M	EUR67.69

*NR: Not rated.*

Notes

Notes



## ANALYST CERTIFICATION

## Appendix A-1

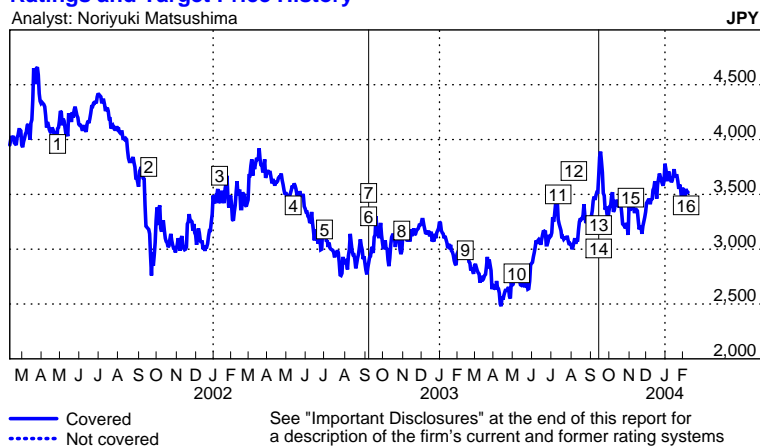
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## IMPORTANT DISCLOSURES

### Toyota Motor (7203)

#### Ratings and Target Price History

Analyst: Noriyuki Matsushima



#	Date	Rating	Target Price	Closing Price
1:	26 Apr 01	*1H	*5,500	4,100
2:	18 Sep 01	1H	*4,600	3,180
3:	16 Jan 02	1H	*5,100	3,480
4:	15 May 02	1H	*5,300	3,560
5:	2 Jul 02	1H	*4,000	3,170
6:	6 Sep 02	Stock rating system changed		
7:	6 Sep 02	1H	4,000	2,875
8:	31 Oct 02	1H	*4,300	2,980
9:	17 Feb 03	1H	*4,200	2,980
10:	9 May 03	1H	*3,700	2,755
11:	11 Jul 03	*2H	3,700	3,270
12:	6 Aug 03	*1H	*4,100	3,060
13:	12 Sep 03	Stock rating system changed		
14:	12 Sep 03	*1M	4,100	3,670
15:	6 Nov 03	1M	*4,350	3,400
16:	6 Feb 04	1M	*4,600	3,550

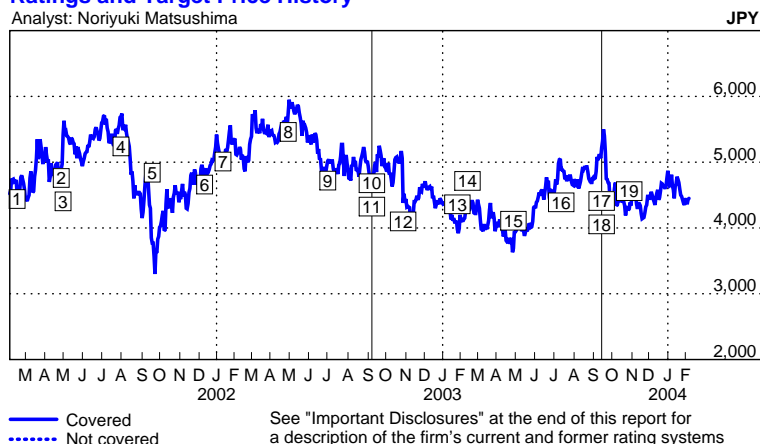
\*Indicates change.

See "Important Disclosures" at the end of this report for a description of the firm's current and former rating systems

### Honda Motor (7267)

#### Ratings and Target Price History

Analyst: Noriyuki Matsushima



#	Date	Rating	Target Price	Closing Price
1:	16 Feb 01	2H	*5,300	4,510
2:	26 Apr 01	*1H	*6,100	4,900
3:	1 May 01	1H	*6,500	5,410
4:	1 Aug 01	1H	*7,000	5,690
5:	18 Sep 01	1H	*5,300	3,770
6:	11 Dec 01	1H	*6,000	4,780
7:	16 Jan 02	1H	*6,600	5,080
8:	30 Apr 02	1H	*8,600	5,760
9:	2 Jul 02	1H	*6,300	5,020
10:	6 Sep 02	Stock rating system changed		
11:	6 Sep 02	*2H	6,300	4,780
12:	29 Oct 02	2H	*5,800	4,380
13:	29 Jan 03	*3H	*4,200	3,980
14:	14 Feb 03	*2H	*4,600	4,330
15:	28 Apr 03	*3H	*3,600	3,690
16:	11 Jul 03	3H	*4,500	4,870
17:	12 Sep 03	Stock rating system changed		
18:	12 Sep 03	*3M	4,500	5,220
19:	29 Oct 03	*2M	*4,650	4,290

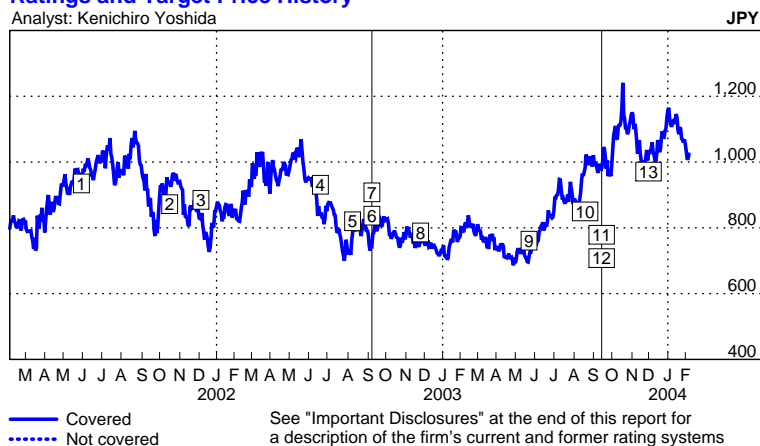
\*Indicates change.

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### Mitsubishi Corp. (8058)

#### Ratings and Target Price History

Analyst: Kenichiro Yoshida



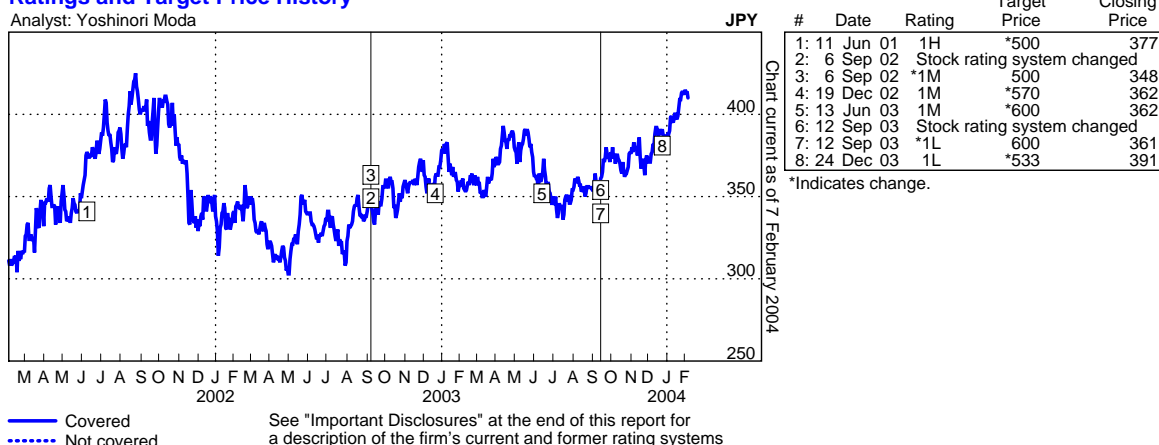
#	Date	Rating	Target Price	Closing Price
1:	31 May 01	2M	*1,200	944
2:	17 Oct 01	2M	*1,100	937
3:	5 Dec 01	*1M	*1,300	826
4:	20 Jun 02	*2M	*1,200	844
5:	8 Aug 02	*1M	1,200	784
6:	6 Sep 02	Stock rating system changed		
7:	6 Sep 02	1M	1,200	744
8:	26 Nov 02	1M	*1,040	756
9:	23 May 03	1M	*988	713
10:	19 Aug 03	1M	*1,100	983
11:	12 Sep 03	Stock rating system changed		
12:	12 Sep 03	*2M	1,100	980
13:	1 Dec 03	*1M	*1,240	1,029

\*Indicates change.

See "Important Disclosures" at the end of this report for a description of the firm's current and former rating systems

## Tokyo Gas (9531) Ratings and Target Price History

Analyst: Yoshinori Moda



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Data current as of 31 December 2003

	Buy	Hold	Sell
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% of companies in each rating category that are investment banking clients	48%	42%	36%
Auto Manufacturers -- Japan (12)	33%	50%	17%
% of companies in each rating category that are investment banking clients	100%	100%	100%
Trading Companies -- Japan (6)	83%	17%	0%
% of companies in each rating category that are investment banking clients	100%	100%	0%
Utilities -- Japan (3)	33%	67%	0%
% of companies in each rating category that are investment banking clients	100%	100%	0%

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Investment ratings are determined by the ranges described above at the time of initiation of coverage, a change in risk rating, or a change in target price. At other times, the expected total returns may fall outside of these ranges because of price movement and/or volatility. Such interim deviations from specified ranges will be permitted but will become subject to review by Research Management. Your decision to buy or sell a security should be based upon your personal investment objectives and should be made only after evaluating the stock's expected performance and risk.

Between September 9, 2002, and September 12, 2003, Smith Barney's stock ratings were based upon expected performance over the following 12 to 18 months relative to the analyst's industry coverage universe at such time. An Outperform (1) rating indicated that we expected the stock to outperform the analyst's industry coverage universe over the coming 12-18 months. An In-line (2) rating indicated that we expected the stock to perform approximately in line with the analyst's coverage universe. An Underperform (3) rating indicated that we expected the stock to underperform the analyst's coverage universe. In emerging markets, the same ratings classifications were used, but the stocks were rated based upon expected performance relative to the primary market index in the region or country. Our complementary Risk rating system -- Low (L), Medium (M), High (H), and Speculative (S) -- took into account predictability of financial results and stock price

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Prior to September 9, 2002, the Firm's stock rating system was based upon the expected total return over the next 12 to 18 months. The total return required for a given rating depended on the degree of risk in a stock (the higher the risk, the higher the required return). A Buy (1) rating indicated an expected total return ranging from +15% or greater for a Low-Risk stock to +30% or greater for a Speculative stock. An Outperform (2) rating indicated an expected total return ranging from +5% to +15% (Low-Risk) to +10% to +30% (Speculative). A Neutral (3) rating indicated an expected total return ranging from -5% to +5% (Low-Risk) to -10% to +10% (Speculative). An Underperform (4) rating indicated an expected total return ranging from -5% to -15% (Low-Risk) to -10% to -20% (Speculative). A Sell (5) rating indicated an expected total return ranging from -15% or worse (Low-Risk) to -20% or worse (Speculative). The Risk ratings were the same as in the current system.

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