

Japan's Energy Policy: Working Together to Provide Clean Air and Abundant Energy for a Better Future

By Diane T. Hooie

Global climate changes occur naturally with time and evolution. However, mankind has affected many climate changes through population growth and, beginning with the Industrial Revolution, through agricultural and industrial practices. Greenhouse gases, which have been said to exacerbate global climate change, include those that are naturally occurring (carbon dioxide [CO₂], methane, nitrous oxides [NO_x] and ozone) and those that are generated exclusively by human activities (hydrofluorocarbons [HFCs], perfluorocarbons [PFCs] and sulfur hexafluoride [SF₆]).* These gases come from a number of sources including manufacturing/industrialization, waste incineration, energy production and deforestation. Although energy production only leads to a portion of the emissions, it has been easy to focus on power plants as a point source to reduce emissions in the future.

In Japan, 90 percent of CO₂ emissions are energy related, of which 8 percent is solely due to power generation, 24 percent is transportation and the balance is from the industrial sector. In 1997, Japan had 296.7 million metric tons of carbon emissions, which are almost 5 percent of the world's total. Of this, oil accounts for 62.5 percent, coal for 25 percent and natural gas for 12.5 percent.¹

Behind the United States, China and Russia, Japan is the world's fourth largest energy consumer. Although Japan is one of the largest energy consumers, it is one of the least energy-intensive countries. Since Japan has very few natural resources and is heavily dependent upon imported fuels, when an energy crisis occurs, the impact is rapidly felt. In 1974 and again in 1981, Japan had major energy crises, which resulted in measures to increase energy efficiency. Japanese cement, chemical and steel industries have attained some of the highest efficiency levels in the world. To ensure that this high level of efficiency continues, the country's energy-savings law ("Law for Rational Use of Energy," April

1999) mandates that energy-intensive companies report and account for their energy consumption and develop plans for reducing the amount of energy used.

In the energy generation sector, using less-carbon-intensive fuels, improved energy technologies and emission clean-up technologies can reduce CO₂ emissions. Japan proposes to reduce its emissions through the installation of clean power generation. A major element of this plan is building new nuclear power plants, but it also includes developing other fossil fuel technologies. Energy forecasters agree that coal and other fossil fuels will continue to be the dominant fuel for energy generation in the foreseeable future. By 2050, it is predicted that Japan's economy will be methane-(natural gas) based and after that it will evolve to reliance on a non-carbon-based energy source such as hydrogen, nuclear renewables (such as solar and wind) or other yet-to-be-developed fuel sources.

With the United States Department of Energy, Japan has partnered to develop and demonstrate clean, energy-efficient technologies to meet near- and mid-term needs. Joint technology exchanges are ongoing in the areas of clean coal technologies, zero-emission power plants of the future and fuel cells. In addition, a joint project with Norway on carbon sequestration has begun.

USING ABUNDANT FUEL: CLEAN COAL POWER GENERATION

Coal is one of the cheapest and most abundant fuels available worldwide, and its use worldwide is expected to increase. Currently, about 56 percent of the electricity generated in the United States is from coal. Although there is significant pressure to reduce this amount, and natural gas usage is increasing, it is projected that energy generation will continue to be dominated by coal. By 2010, over 50 percent of the energy generated in the

*Source: U.S. Environmental Protection Agency, Global Warming Website (<http://www.epa.gov/globalwarming/>)

United States will still be from coal, while in Japan coal will continue to account for at least 15 percent. Since the oil crisis of 1974, Japan's dependence on coal has increased. For other developing nations, coal consumption is expected to double.²

Increased coal use must be balanced by improved technology to increase efficiency, which reduces consumption and aggregate emissions, and eliminates the adverse impacts from emissions. Unfortunately, this is not without increased cost. Emissions control technology under development in both the United States and Japan could greatly reduce the cost of complying with future regulations and keep coal as a viable fuel for power generation. Current control technologies have proven effective at reducing emissions by a factor of two or three at low incremental costs, but much more remains to be done.

Worldwide, the coal power industry faces two major challenges: more stringent environmental regulations (many promulgated by the Kyoto Protocol) and cost-cutting pressures associated with deregulation and privatization. In Japan, privatization of power supplies for the industrial sector has already begun. While the cost of energy to this sector is expected to decrease, funding for development of cleaner technologies will also decrease due to lower revenues.

In Japan in 1973, the former Agency of Industrial Science and Technology (AIST), Ministry of International Trade and Industry, initiated the "Sunshine Project" to develop technologies associated with new energy sources. These included coal gasification and liquefaction. In 1978, the "Moonlight Project" for energy conversion was started, followed by the R&D project on Environmental Technology in 1979. These projects were consolidated into the "New Sunshine Program" in 1993.

The "New Sunshine Program" today attempts to harmonize the three key elements of the Japanese energy policy: energy security, the environment and the economy. In order to use coal in ways that are more "environmentally friendly" and to secure a stable supply of coal imports, Japan is developing clean coal projects to support this program. Today, a coal liquefaction pilot plant, with a capacity of 150 tons/day, has been demonstrated in Japan. This plant, which is supported by a process support unit (PSU) of 1 ton/day, has provided a high liquid yield and a highly reliable

operation. Basic research on the liquefaction technology has been continuously carried out at Japanese and U.S. national laboratories.

In Japan, liquid natural gas (LNG) use is continuing to increase. Because LNG is a costly major import, Japan has focused on developing an economically viable and efficient synthetic natural gas (SNG) production process. Using coal as the feedstock and hydrogen as the gasification agent, about 50 percent of the coal can be converted into gas. This whole process, from coal mining to burner tip, could reduce carbon emissions by a factor of four.

CLEANER AIR THOROUGH SEQUESTRATION

In addition to cleaning up their power plants, Japan and the United States have been jointly examining options for mitigating CO₂ emissions. Some non-technical options, such as reducing population and reducing gross domestic product (GDP), while theoretically possible, are really not practical. Two technical options have already been discussed: reducing carbon intensity and improving efficiency. The third option under study is to sequester carbon, both directly and indirectly.

For direct sequestration, CO₂ can be collected directly from the power plant or other large point sources and pumped elsewhere for long-term disposal. Sequestration can also be used to sweep the gas from unmineable coal seams, producing methane. Depleted oil and gas reservoirs, saline aquifers or the ocean can be used for disposal. For indirect sequestration, CO₂ must be captured after it has been released into the atmosphere by enhancing or accelerating natural absorption processes. Possible approaches include iron or nitrogen fertilization of the ocean, forestation, photosynthesis of algae (and the creation of algae farms) and alternate land management practices. Obviously, for this technology to be broadly applicable, it must be safe, have minimal environmental impact, leave no adverse environmental legacy for future generations, constitute a permanent and complete solution and be cost effective.

Sequestration is technically feasible. The United States has been partnering with Japan, Norway, Canada and a private Swiss corporation on an experiment to sequester CO₂ in the ocean. This is one of six projects the United States funds in this area.

FUEL CELLS—THE PROMISE OF THE FUTURE IS HERE TODAY

In both Japan and the United States, fuel cell power generation technology is regarded as one of the most important new clean energy sources. Fuel cells are an electrochemical method of producing energy and have high efficiency and low emissions. Their operation is much like a battery, but they continue to operate as long as they are supplied with a fuel and oxidant (air). They operate using any hydrogen-rich fuel supply, such as natural gas, methanol, gasoline, coal gas, etc. The products from this reaction produce electricity, heat and water. The heat can also be captured to provide additional energy or to meet space and process heat needs. Fuel cell technology powers the space shuttle's electrical and heating/cooling needs while it is in space.

Currently, four types of fuel cells are under development: polymer electrolyte (PEMFC), phosphoric acid (PAFC), molten carbonate (MCFC) and solid oxide (SOFC). The PEMFC systems will be used primarily in residential and transportation applications. Ford, Daimler-Chrysler, Honda, Toyota and Nissan have all developed and demonstrated fuel cell powered automobiles, which are available in limited quantities. Small systems (up to 30-kW) are also being developed for residential and small buildings.

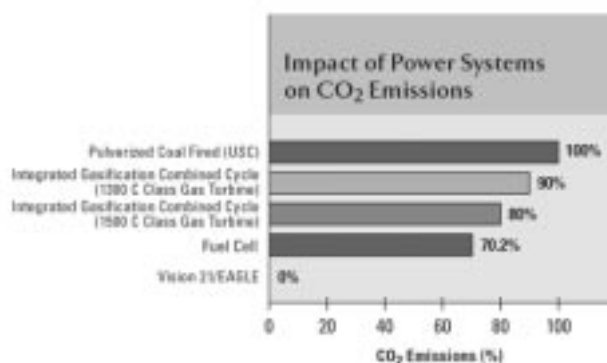
Demonstrations of larger systems (200-kW to 11-MW) have been conducted both in Japan and the United States. These systems can be used for distributed generation (placing the power source near the end use). PAFC systems in the 200-kW size range are commercially available, and over 215 units have been installed, about 40 percent of them in Japan, which have compiled over 4 million hours of operation. During 1999 and 2000, a 1-MW MCFC system was built and demonstrated in Kawagoe, Japan. The most efficient systems, fuel cell hybrids, can have efficiencies that are twice as high as conventional coal technologies, while still producing negligible emissions. Programs in both the United States and Japan are providing demonstrations of this technology to verify reliability and maintenance costs; technology research programs are also addressing the high cost of these systems.

THE ZERO-EMISSION POWER PLANT OF THE FUTURE

The ultimate in clean energy systems—the zero emission technology of the future—is known in the U.S.

Department of Energy as “Vision 21” and in Japan as “EAGLE” (Coal Energy Application for Gas, Liquid and Electricity). This program is designed to effectively remove environmental concerns associated with using fossil fuels to produce electricity and transportation fuels at a competitive cost. This can be accomplished through an optimized, integrated combination of high-efficiency, direct power generation technologies such as coal gasification and a fuel cell-combined cycle (using steam turbine, gas turbines and fuel cells). The efficiency is projected to be almost double to triple today's rate (as high as 60 percent for coal to electricity, 75 percent for gas to electric and 75 percent for fuel production) with near zero emissions. Components for these systems will be demonstrated during the next few years, with commercial plant designs by 2015.

Figure 1. Impact of Power Systems on CO₂ Emissions



SUMMARY

All of the technologies discussed here can decrease greenhouse gas emissions by reducing carbon intensity and improving efficiency (see Figure 1). A portfolio of options to reduce greenhouse gases as needed, including power generation technology and carbon sequestration. A “technology gap” exists between where we are today and where we need to be to stabilize atmospheric CO₂ “at a level that would prevent dangerous anthropogenic interference with the climate system.”⁷³

Changing our current energy system overnight is not feasible; premature retirement of our existing infrastructure is prohibitively expensive. It is essential that we conduct research now into new technologies so we have the tools to cost-effectively address emissions over the longer term. Developing and implementing

these technologies will not be cheap and will result in increased energy costs. However, the public and health benefits of these cleaner technologies must also be considered. Investing wisely in technology development and working together will help us minimize the cost and accelerate our ability to stabilize greenhouse gas concentrations. ❄️

Diane Hooie has over 28 years of experience converting new ideas and innovative technologies from the concept stage through production and to profitable marketable products. For the last 10 years, Dr. Hooie has been working on new, clean energy technologies with the Department of Energy (DOE). Currently, she is a Senior Advisor, U.S. Department of Energy, National Energy Technology Laboratory, Strategic Center for Natural Gas, where she is responsible for developing technical cooperation with non-traditional DOE customers as well as Russia and Japan. From 1997-99, Dr. Hooie served as a Mike Mansfield Fellow at Japan's Ministry of International Technology and Industry, Agency of Science and Industry and Agency of Natural Resources, and the National Energy Development Organization. She holds a B.S. in ceramic engineering from Ohio State University, an M.Sc. in engineering management from Rensselaer Polytechnic University and a Ph.D. in engineering from California Coast University. Her e-mail address is dhoocie@netl.doe.gov.

¹ Energy Information Administration, "Japan: Environmental Issues," November 1999.

² Smouse, Scott M., Ekmann, James M., and Schmidt, Charles E., "Environmental Issues Affecting Coal-Fired Power Plants - U.S. DOE's Programmatic Response" (paper presented at The 16th Japan/U.S. Joint Technical Meeting [Advanced Clean Coal Technology], Fukuoka, November 7-8, 2000.)

³ Bajura, R., "CO₂ Sequestration as a Viable Response to Climate Change" (paper presented at The 16th Japan/U.S. Joint Technical Meeting [Advanced Clean Coal Technology], Fukuoka, November 7-8, 2000.)