Technologies for Reducing Greenhouse Gas Emissions — Strategic Outlook

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Executive Summary

At present, any substantial cut in global greenhouse gas emissions could only be achieved by substantial reductions in global economic output, even if all countries were to contribute to the emission cuts. If the emission cuts were confined to industrialized and transition economies, as the Kyoto Protocol envisages, the loss of global economic output would be even greater. This would adversely affect the developing countries, notwithstanding their exemption under the Protocol.

The Kyoto Protocol ignores the critical role that technological progress has to play in creating the ability to cut emissions without compromising living standards, either now or in the future. It also ignores the long lead times that will be involved in realizing that technical knowledge, and ignores the role that public research will have to play in establishing the basic science that underpins them.

In recognition of this oversight, Australia, China, India, Japan, the Republic of Korea, and the United States launched the Asia-Pacific Partnership on Clean Development and Climate (AP6), in 2006. AP6 seeks to identify and develop technologies and processes to reduce emissions without penalizing economic growth.

This strategic review outlines the considerable scope that exists to accelerate the rate of technological progress in cutting greenhouse gas emissions by:

- Increasing energy efficiency;
- Capturing and storing emissions;
- Reducing the carbon-intensity of the energy mix; and
- Reducing emissions from productive processes other than energy consumption.

Increasing Energy Efficiency

Accelerating energy efficiency is essential. There is substantial scope for gains right across the major energy using sectors — commercial and residential buildings, industry and transport.

In the case of new *buildings*, energy efficiency gains of up to 70 percent could be achieved with:

- Better building design, including the incorporation of passive solar features;
- Thermally resistant windows and insulation;
- State-of-the-art heating and cooling systems; and
- Energy-saving appliances, such as washers, refrigerators and computers.

Most of these technologies are available or being commercialized.

In *industry*, significant energy efficiency gains are generally available through:

- Replacing motors, pumps, boilers, and heating systems;
- Increasing the use of waste;
- Adopting new materials and processes; and
- More efficient use of materials.

Additional efficiency gains can be made in the most emission-intensive industries — iron and steel, cement, chemicals, petrochemicals, pulp and paper, and aluminum. In these sectors break-through technologies on the horizon include direct casting in iron and steel, advanced membranes in chemicals and petrochemicals, the use of biomass feedstock in petrochemicals, and black liquor gasification in pulp and paper.

Energy efficiency is critically important in the *transport* sector given its near-total reliance on crude oil. The most promising technologies include:

- Hybrid vehicles with electric motors and internal combustion engines;
- Advanced diesel engine designs;
- Turbochargers, fuel injection and computerized engine management systems;
- Lighter materials; and
- Efficient on-board appliances, such as air conditioners.

Capture & Storage of Emissions

The capture and storage of CO_2 emissions from burning fossil fuels is likely to make a dramatic difference in time, particularly in electricity generation and other emission-intensive industries such as iron and steel.

At present the cost of capture and storage is generally high, but technological progress should reduce the cost to commercially acceptable levels, at least over the long run. Some applications are already economical and well-established, such as the use of captured CO_2 to enhance the recovery rate of crude oil.

Decarbonizing the Energy Mix

Much can be done to reduce the carbon-intensity of the mix of energy sources that are used for economic activity. The biggest gains are in electricity supply, where a wide range of technologies beckon, including natural gas, nuclear and renewable energy.

Natural gas generation emits half the CO_2 per kWh as conventional coal technologies. The switch from coal to gas in electricity supply, combined with progressive improvements in the energy efficiency of gas-fired generation, has already had a major impact in restraining emissions from the electricity supply sector. There is, nevertheless, ample scope to continue, if not accelerate, both trends.

Nuclear power and renewable energy have the potential to generate virtually limitless energy with no significant greenhouse gas emissions.

Eleven countries, including those with the largest nuclear power sectors, are developing the next generation of nuclear power plants in ways that address the major impediments to the expansion of nuclear power — high capital costs, the risks

posed by nuclear waste and accidents, and the proliferation of nuclear weaponry.

In time *renewable energy* could supply up to one-third of global energy requirements.

- Hydropower is a well-established technology that can generate power quickly and cheaply. It has considerable scope for expansion, particularly for small scale plants in developing countries.

- Wind power has good potential to replace fossil fuel-fired generation, particularly given economic systems for energy storage, such as pumped storage hydropower.

- Biomass is a well-established fuel and is extensively used around the world. It is easily co-fired with coal in power generation with little or no modification to the generation plant.

- The potential of geothermal power is very substantial. Although development costs have dropped, high temperature geothermal resources remain site-specific. The ability to exploit low temperature resources is being commercialized.

- Solar photovoltaic technologies are rapidly gaining ground in commercial applications as their capital costs decline as a consequence of research and development. Concentrating solar power technologies are also promising.

In the *transport* sector the biggest challenge is to find replacements for the fuels that are derived from crude oil and the engines that run on them.

Ethanol derived from biomass has good prospects over the short to medium term. It can be blended with gasoline and used in the current motor vehicle fleet without modification. At present research and development is actively focused on expanding the range of economic feedstocks for ethanol production.

In the longer run, hydrogen fuel cell technologies could virtually eliminate greenhouse gas emissions from road transport. At present, however, they are very expensive and their widespread acceptance will require enormous investments in the infrastructure to make and distribute hydrogen to end-users.

Reducing Emissions from Non-Energy Sources

Significant fugitive emissions of methane and nitrous oxide from the agricultural and mining sectors are not associated with energy use. More significant is methane, as it is thought to be 20 times more effective at trapping heat than CO_2.

There is considerable scope to reduce these emissions:

- Methane emissions from livestock can be reduced thorough animal husbandry and feed management.

- Stored *livestock manure* emits methane and nitrous oxides, which can be reduced with the use of anaerobic digesters or by composting.

- Nitrogenous *fertilizers* can cause soil nitrification and denitrification. They can generate nitrous oxide emissions, which can be cut by fertilizer management.

- *Paddy rice* generates methane emissions, which can be cut by changing the cultivars used, irrigation management, direct seeding of rice, and the use of methanogenesis inhibitors, such as ammonium sulfate.
- Methane emissions from *mining* can be reduced by minimizing fugitive losses from gas transmission and distribution pipelines.