The Asia-Pacific Partnership on Clean Development and Climate

New Prospects for Joint Strategies on Climate Change

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Introduction

Australia, China, India, Japan, South Korea and the United States (US) have formed the 'Asia-Pacific Partnership on Clean Development and Climate' (APCDC) to collaborate to develop a new approach to climate change.

The formation of this partnership reflects recognition that the strategy set out in the Kyoto Protocol to address climate change by regulating production of energy cannot succeed. It is ineffective for economies which cannot accept strategies that reduce growth.

Any strategy to reduce emissions from the burning of fossil fuels or to reduce the world's reliance on fossil fuels—while meeting the world's need for energy—must have as its starting point the current lack of appropriate technology.[1] At present, fossil fuels supply over 85 percent of all primary energy; the rest is made up of nuclear power, hydro-electricity and renewable energy (largely biomass, geothermal, wind and solar energy). Currently, non-hydro, non-nuclear renewable energy supplies less than 1 percent of the global energy demand.[2]

The goal of the new partnership is to develop existing and emerging cost-effective cleaner technologies and practices to reduce emissions of carbon dioxide and capture and store it. The partnership will focus on concrete and substantial action to achieve practical results.

The Partnership has been announced and is soon to have its first meeting. There is a great deal of interest in what it might do. It includes three of the world's biggest economies, two of the world's most innovative economies, two of the world's most populous economies, the world's biggest consumers of energy and the world's largest producers of energy.

This paper provides a summary overview of the research and development in technologies relevant to an alternative approach to climate change. The aim is to identify possible areas for collaboration and directions of work for the Partnership.

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[1] Hoffert et al. (2002)

[2] US Department of Energy, Energy Information Administration, Annual Energy Review 2004.

Executive Summary

Research in energy in recent years has concentrated on technologies that are not capable of producing power in sufficient volume at an acceptable price to reduce substantially dependence on fossil-based energy sources.

The strategy in the Kyoto Protocol was to reduce emissions of carbon dioxide by increasing the cost of energy derived from fossil fuels. This strategy is not acceptable to economies unwilling to adopt strategies that would dramatically reduce growth.

The Asian Pacific Partnership for Clean Development and Climate (APCDC) offers a different approach – to collaborate in research in technologies which produce greater efficiencies in combustion of fossil fuels, expand the capacities of existing technologies, undertake basic research in new energy technologies and support the capture and sequestration of carbon dioxide.

The members of the partnership have a spread of expertise in these technologies among them. This suggests a means for the Partnership to meet its goals – collaborating in program streams in key technologies. In view of research programs to date, research streams as follows would be practicable:

Program streams for collaboration in the Partnership				
Energy efficiency	China	Japan	USA	
Biomass	China	India	USA	
Nuclear	Japan	Korea	USA	
Wind	USA			
Solar	India	Japan	USA	
Hydrogen/Fuel cell	Australia	Korea	USA	
Carbon capture, storage	Australia	Japan	Korea	USA

The Kyoto Protocol strategy is unlikely to meet one of its professed goals of transferring technology to developing countries to assist them to manage climate change. Achieving this required global participation in Kyoto. Technical assistance under the Global Environment Facility has also focused narrowly on fashionable technologies – eg photovoltaics and biomass—rather than technologies which can produce significant results, like greater efficiency in combustion of fossil fuels.

The Partnership creates an opportunity to set up such new programs of collaborative research and development and invite participation by other economies on the basis of whatever they can contribute. This offers tangible prospects of developing and disseminating technologies which can assist countries to address climate change.

Overview

Trends in research and development in energy

Private and public research into energy efficiency is the most market-driven of activities relevant to the reduction of carbon-dioxide emissions. While energy is very cheap in several of the APCDC nations, industry is constantly seeking avenues for the reduction of costs. Evidence of the positive impact of technology in this area can be seen in the steep decline in ‘energy intensity’ among developed economies (measured as the units of energy required to produce a dollar of GDP).[3]

Research and development spending on renewable energies has come in two waves. The first dates from the time of the oil crises in the 1970s and the second from the early 1990s. The first wave of spending concentrated on nuclear power, hydropower, geothermal and basic biomass. Hydro and nuclear were providing around 12 percent of global energy needs by the late 1990s.[4]

For all these technologies save nuclear, however, there existed finite potential, due to lower power density (in the case of basic biomass), and a limited number of suitable sites (in the case of hydropower and geothermal energy). Nuclear power maintained significant potential, but was politically sensitive.

The second wave of spending on research and development in renewable fuels focused on wind, solar photovoltaics (PV) and advanced biomass. By 2002, the second generation of fuels accounted for around 80 percent of funding for alternative energies.[5] As these technologies have matured, their shortcomings as major alternatives to fossil fuels have become apparent. Solar PV is likely to remain expensive, but cost effective in isolated areas. Wind is projected to become competitive, but as wind energy is difficult to store and the power generated intermittent, it must generally be supported it by separate, core energy source. Advanced biomass has a low power density inherent in the process of photosynthesis.

While these technologies are important and their cost efficiency will continue to improve, these sources are widely viewed as insufficient as mainstream alternatives to fossil fuels. A group of scientists commented in 2002 (Hoffert et al.) that the current mainstream suite of renewable energies did not imply a path from core dependence on fossil fuels before 2050. These limitations have led to calls for pure research, independent of the established renewable energies, with a view to sparking entirely new responses. The most important outcome of this sort of research has been recent innovations in fuel cell technology. Research has also begun into ways that fossil fuels might continue to be exploited while controlling carbon emissions. This has involved research into carbon capture and sequestration.

The technologies examined in this paper can be divided into three groups:

- Energy efficiency and conservation
- Non-carbon based fuels
- CO_2 capture and storage

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[3] Using the simple energy/GDP ratio, the energy needed to produce a dollar's worth of goods and services in the U.S. economy fell by more than half between 1949 and 2002. Source: EU DOE, Office of Energy Efficiency and Renewable Energy.

[4] EIA 2000a International Energy Annual 1998 Energy Information Agency under US Department of Energy.

[5] Sellers (2004).

Energy dependency of members of the Partnership

Members of the Partnership are heavily dependent on fossil fuels for energy. (Their position is similar to most developing countries.)

Fossil fuel share of energy consumption, percentage by country

	Coal	Oil	Gas
Australia	44	25	17
China	65	25	3
India	55	35	6.5
Japan	50	19	13
South Korea	21	54	11
USA	23	40	23

Source: US Department of Energy national energy briefs, various editions.

The countries in the Partnership have varied natural resources endowments and energy strategies.

Australia is rich in energy resources, with significant petroleum, natural gas and coal reserves. Australia's energy consumption is dominated by coal, which fuels most of the country's power generation. Australia is the world's largest coal exporter. Petroleum accounts for a large share of energy consumption. Natural gas use is small, but has been growing rapidly. Australia is facing growing dependence on petroleum imports.

China has become the world's third largest oil consumer after the US and Japan. With an annual rate of increase of 4 percent in oil consumption experienced in the past 20 years, China's oil consumption reached 210 million tons in 2003. China's domestic oil production capacity is limited. Consequently, China became a net oil-importing country in 1993, and the amount of imported oil by China reached 70 million tons in 2000, accounting for 30 percent total oil consumption. A major cause of the increase in Chinese oil consumption can be attributed to the rapid growth of the transportation sector in motor vehicles in particular (He, Hong et al., 2005). Coal makes up 65 percent of China's primary energy consumption, and China is both the largest consumer and producer of coal in the world. China's coal consumption in 2003 was 1.53 billion short tons, or 28 percent of the world total. Natural gas currently accounts for only around 3 percent of total energy consumption in China, but consumption is expected to nearly double by 2010. This will involve increases in domestic production and imports by pipeline and in the form of liquefied natural gas (LNG).

India is the world's sixth largest energy consumer and the world's third largest producer of coal. The country relies on coal for more than half of its total energy needs. Oil accounts for about 30 percent of India's total energy consumption. India consumption of natural gas has risen faster than any fuel in recent years.

Japan is the world's fourth largest energy consumer and second largest energy importer (after the United States). Japan lacks significant domestic sources of energy and must import substantial amounts of crude oil, natural gas, and other energy resources, including uranium. In 2002, the country's dependence on fossil fuel imports for primary energy stood at more than 80 percent. Japan's energy intensity (energy use per unit of GDP) is among the lowest in the developed world.

South Korea is the world's fifth largest oil importer, and the second largest importer of LNG. With no domestic oil reserves, South Korea must import all of its crude oil. Most of South Korea's coal and gas is also imported, though the country began producing a small quantity of natural gas from on offshore fireld in November 2003.

The USA is the world's largest energy producer, consumer, and net importer. It also ranks eleventh worldwide in reserves of oil, sixth in natural gas and first in coal.[6]

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[6] Source: US DOE/IEA national Energy Briefs, various countries.

Technologies, research

I. Energy efficiency and conservation

Growth in air pollution[7] no longer mirrors economic growth directly. In countries where gross domestic production per person has exceeded US$2,000 per head, levels of particulate pollution, sulfur dioxide, ozone, nitrogen oxides and lead in the air have fallen dramatically.[8]

Research in efficiency in building, products, production and transport has been led by the two nations with furthest developed technologies of production, the United States and Japan. While the United States has delivered the greatest gains in efficiency of production and manufacturing, Japan has developed cutting-edge efficiency in private transportation. Meanwhile, important research is emerging from China about the potential for increased energy efficiency through enhanced production, design and manufacturing processes.

In the United States, technology improvements in building equipment, appliances and lighting have focused on improved engineering and new materials. The Department of Energy reports enhanced efficiencies in household and industrial appliances and equipment over the last 20 years of between 15 percent to 75 percent.[9]

Japan still leads the world in efficient private transportation. In 2003, eight of the top 10 most fuel-efficient models available in the US were Japanese-made cars, led by the Honda Insight hybrid (EPA/DOE, 2003).

At a the level of applied research, the Global Climate and Energy Project (GCEP), coordinated by Stanford University,[10] is working to optimise methods of kinetic combustion and 'low-irrersibility' combustion whereby the combustion of the reactant is controlled in various innovative ways to harness extra energy output.

Recent research from the Institute of Energy, Environment and Economy at Qinghua University, China's leading university for research in applied science and engineering, has focused on technology and product developments as sources of increased energy efficiency. In China, energy consumption for construction and transportation has risen rapidly in recent years.[11] Findings suggest 20 to 30 percent of this increased energy use could be saved. The research suggests also suggests China should focus on indirect energy savings, by increasing the value-added of products, optimising product and industry structures and improving production technologies (He et al., 2005; Jiankun and Xiliang Zhang, 2002). The research suggests potential of indirect energy savings in China is more significant than in many developed economies.

II. Alternative fuels

Biomass

Biomass is an important alternative to fossil fuels in countries such as India and China, where electrification in remote areas is often limited.

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[7] In the 'criteria pollutants', or those pollutants for which the US EPA has established national Air Quality Standards. They are: sulfur dioxide, ozone, lead, nitrogen oxides and carbon dioxide.

[8] EPA, 1996; EPA, 2000, 2000a; DETR, 1993; CEQ, 1993.

[9] U.S. DOE, 2003.

[10] The Global Climate and Energy Project (GCEP), coordinated out of Stanford University in the USA, is a long-term research effort bringing together the world's leading scientists from universities, research institutions and private industry to focus on pre-commercial technologies.

[11] China annually adds more than 1 billion m^2 of new housing un urban and rural areas. By 2020, the square footage of buildings in China will be two times that in 2000 and the energy consumption for residential heating will be three times that in 2000. The ratio of energy consumption for residential heating to the overall energy consumption for residential heating will be 3 times that in 2000. The ratio of energy consumption for residential heating to the overall energy consumption will reach 30 percent from 20 percent in 2000.

Energy from biomass is difficult to transport and to store, and photosynthesis has too low a power denisty[12] for biofuels to provide mainstream, baseload energy. Stanfords' GCEP is examining opportunities to develop plant varieties that would overcome the limitations of current biomass technology.

Small programs of research exist in Australia (CSIRO, 2005) and Japan (PNWL, 1995) but research has been relatively limited. Research in Japan has focused on advanced biomass: small-scale, highly efficient biomass conversion plants (Matsumura, 2005). In 2003 the biomass division of Japan's Institute of Energy (an independent research organisation) completed comprehensive research into the potential for biomass as an alternative energy source, using wood, agricultural waste municipal waste, livestock manure and energy crops. Research in the US has focused on using sugar or glycerides as a platform for producing fuels, through hydrolysis, followed by microbial or catalytic conversion, or through thermochemical transesterification of triglycerides.

Research and development related to biomass in China extends back some years, with significant activity in the late 1990s.[13] Research has shown biomass gasification and power generation can reach reasonable efficiency at a certain scale. China is rich in biomass resources: rice and timber are major industries in China and provide suitable fuel (Wu et al., 2002).[14]

Nuclear

Among the countries in the Partnership, research into nuclear power is furthest advanced in the United States and Japan.

The Japanese energy research and development portfolio is heavily skewed towards support for nuclear technologies. In 1997, fission energy research and development (R&D) accounted for 66 percent of all Japanese energy R&D.[15] When fusion R&D is added to this, the percentage of the public energy R&D budget accounted for by all nuclear energy R&D was 75 percent. Around 80 percent of the public expenditure on research in to nuclear fission is directed at the nuclear fuel cycle, decontamination and geologic disposition research and not on new reactor concepts. Even with this decrease, the Japanese fission program was still in excess of US$1.5 billion dollars in 1997, a figure which was larger than the combined total nuclear energy R&D programs of the European Union.

In the United States, around 20 percent of electricity requirements are fueled by nuclear power. Recently research efforts have focused on increasing the efficiency, reliability, and power generation of existing nuclear power plants (DOE, 2003).

Hydrogen

The use of hydrogen as fuel comprises the production of molecular hydrogen using coal, natural gas, nuclear energy or renewable energy (e.g. biomass, wind, solar); the transport and storage of hydrogen and the end use of hydrogen in fuel cells, which combine oxygen with hydrogen to produce electricity (and some heat). Hydrogen is inherently expensive and inefficient to produce, transport, store and distribute—thus technological breakthroughs will be needed to reduce the overall cost of using hydrogen as a transport fuel (Dorian *et al*., 2004). Rapid improvements in the proton exchange membrane fuel cell (PEMFC) during the pas decade have been a catalyst for

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[12] Around 0.6 W m-2, (Hoffert et al 2002: 982).

[13] Wu et al., 2002.

[14] Experiments in circulating fluidisd bed gasifiers have been carried out at the Guangzhou Institute of Energy conversion. Waste rice husk from the rice mill was fed to the CFB gasifier, the gas produced was cleaned in cyclones followed by Venturi-tube and water scrubbing, then the clean gas was stored in a gas tank and used to drive gas engine/power generator sets. Similar experiments in Hainan Province at higher capcities. Waste water treatment and system efficiency need further development (Wu et al. 2002).

[15] Pacific Northwest National Laboratory, (1999) *Japan: Analysis of Energy R&D Programs*, PNNL Energy Trends Series.

this renewed interest in a hydrogen economy because of the fuel cell's potential in transportation applications.

In the United States, research into the possible application of hydrogen as a fuel source has been extensive. Debate continues over the timeframe for rendering hydrogen competitive (Hammerschlag & Mazza, 2005; Rifkin and Clark, 2005). In transport, the US has completed significant long term research in to hybrid electric vehicles. The ultimate goal for these vehicles is that they run fuel cells that convert fuels to electricity directly. Although fuel cell-powered vehicles may initially run on gasoline or other fuels reformed to produce hydrogen, the ultimate goal is that they run powered by hydrogen stored on board.

Australia has pioneered research into the solid oxide fuel cell, designed to convert hydrogen directly into electricity (CSIRO, 2002: vii).[16] Vehicles using hydrogen stored on board produce only water as a tailpipe emission. Further research is required into energy storage systems, electrochemical batteries and ultracapacitators.

In the US, research has been carried out on very high temperature, high efficiency nuclear power plants can produce electricity to electrolyze water vapour and supply temperatures high enough to drive chemical cycles for hydrogen production (DOE, 2003).

South Korea has developed a hydrogen powered transportation plan that seeks to cut the nation's dependence on fossil fuels by 20 percent by 2020. The Ministry of Science and Technology has allocated $986 billion won (US$843 million) until 2020 to fund the creation of this hydrogen energy supply, which will come almost exclusively from nuclear reactors (Asia Pulse, 2004). The plan calls for three research institutes—the Korea Atomic Energy research Institute, the Korea Institute of Energy Research (KIER) and the Korea Institute of Science and Technology (KIST)—jointly to conduct R&D for the relevant technologies. Most of the research at the KIST and KIER is focused on electro-catalytic production of hydrogen, hydrogen storage and fuel-cell technologies. Fuel-cell research is proceeding in the following directions: direct methanol fuel cells (DMFCs) for portable power, polymer electrolyte membrane fuel cells (PEMFCs) for automobiles, molten carbonate fuel cells for large-scale power plants and solid oxide fuel cells for stationary power (Kim et al., 2004; KIER, 2004).

Almost all of the major car companies have active programs to develop hydrogen vehicles GM, Ford and DaimlerChrsyler have all developed hydrogen vehicles. Fossil fuel majors, BP, Royal Dutch Shell, Chevron Texaco and Exxon Mobil have also all been involved in research into hydrogen fuel. Overall private spending hydrogen energy R&D dwarfs spending by governments.

The entry of hydrogen into the renewable energy scene in India has been fairly recent, however, and so far mostly limited to R&D and a few demonstration projects. Work in fuel cells is somewhat more advanced, with collaboration between Baharat Heavy Electricals Ltd., the Tata Energy Research Institute, the Central Electrochemical Research Institute and the Indian Institute of Science, among others.

Solar PV

GCEP has a range of programs directed towards solar technology, focusing mainly on the development of a variety of nano-structured, low cost, fine film solar cells. The US Department of Energy's own research solar PV program focuses on improving materials and deposition and improving manufacturing processes.

Australia leads the world in developing photovoltaic cells that allow a greater amount of the sun's energy to be trapped in a smaller area (CSIRO, 2005).[17] CSIRO, the Australian Government's

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[16] Ceramic Fuel Cells Limited in Australia is currently processing the solid oxide fuel cell. has developed a solid oxide fuel cell the size of a 2-litre milk carton that produces 1.5 kilowatts, enough power to meet the needs of a typical household.

[17] CSIRO (2005) *Energy Information Sheet*

research agency, is developing a new technology for capturing solar energy, using a Solar Concentrator Dish in such a way that it can be stored or transported to where the energy is required. Another major project uses solar energy to reform natural gas (methane) and steam into a mixture of CO^2 and hydrogen (CSIRO, 2005).

India has one of the largest national programs to promote the use of solar energy, because in areas not connected to centralised power, solar PV can be an economical source of energy. Deployment of small, stand alone solar PV systems in India stood at 610,000 in 2004, equating to over 20 MW of power (Mukhopadhyay, 2004). In Japan, leading work on solar energy has focused principally on reducing the cost of mass production of PV cells.

Wind

Research into windpower is furthest advanced in Europe, although the US and India have relatively large capacity.[18] In the US, government-funded R&D into leading innovative platforms for wind power (Musial & Butterfield, 2004).

To explore offshore floating wind turbine concepts, the Wind Program at the NREL awarded a conceptual design study to the Massachusetts Institute of Technology (MIT) in late 2004. The program devises concepts for off-shore floating platforms for generating wind energy, in water depths between 50 and 200 meters. The Sandia National Laboratories, based in Albuquerque, New Mexico, have conducted research into wind turbines, specifically in advanced manufacturing, component reliability, structural analysis, and material fatigue.

In Australia, scientists have developed a modeling technique that identifies the best sites for wind harvesting. Working with industry, the CSIRO team combined wind monitoring with computer modeling to select the site for Australia's first wind farm connected to a major electricity grid, in Crookwell, New South Wales.

III. CO_2 capture and storage

Processes for CO_2 capture fall into three general categories: (1) flue gas separation; (2) oxy-fuel combustion in power plants; and (3) pre-combustion separation. The earth's crust offers three major classes of geologic formation that appear suitable for long-term storage of CO_2: deep formations containing salt water, unmineable coalbeds, and oil and gas reservoirs.

The GCEP at Stanford University is carrying out leading research in to carbon capture, in particular into advance membrane reactors for carbon-free fossil fuel conversion and the development of gas separation membranes, which would allow for the separation of CO_2 from other gases present in flue or synthesis, the removal and storage CO_2. The Korean Institute of Energy Research (KIER) has also carried out extensive research into replacing part of the adsorptive separation process with membrane technology.

The GCEP is also researching carbon storage, in particular systems to predict CO_2 flow and to optimise injection operations, to examine how these 'coal beds' might be 'sealed' and to monitor the shifting capacity of these beds.

The Carbon Capture and Sequestration Technologies Program at MIT and the Princeton University Carbon Mitigation Initiative have also conducted leading research into technologies to

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[18] The American Wind Energy Association (AWEA) expects 2005 to be a recordbreaking year for the industry, with up to 2,500 megawatts (MW) of new wind energy generating capacity likely to be installed in the U.S (AWEA, Windpower Outlook 2005, AWEA: Washington D.C.; Indian Ministry of Non-conventional Energy Ministry of Non-conventional Energy Sources, Government of India. India is the fifth largest producer of wind power in the world with a wind poewr generation achievement of 1507 MW, of which 1444 MW comes from commercial projects (Mukhopadhyay, 2004). Cooperation with DANIDA, the Danish development agency, has generated improvements in grid connections.

capture, utilise, and store CO_2 from large stationary sources. These technologies are also being put in to practice in a number of privately funded demonstration projects across the US.[19]

The Cooperative Research Centre for Greenhouse Gas Technologies in Australia combines the work of the CSIRO and leading Australian research teams in research into enhanced CO_2 capture systems, energy systems analysis for capture and storage, enhanced risk analysis and environmental assessment techniques, development of best practice for capture and storage. A number of demonstration projects have also been carried out in Australia.

Japan has a range of research projects and demonstration projects related to carbon capture and storage. These include physical absorption post-combustion, solvent absorption, storage in aquifers and the deep ocean, and storage in unmineable coal seams.[20]

In China a number of research projects are also underway, covering sequestration in coal beds and injection of boiler flue gas for enhanced oil recovery in Chinese oil fields.[21]

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[19] Demonstration projects include solvent absorption at Shady Point Power Plant, Oklahoma, the Warrior Run Power Plant, Maryland; Bellingham Cogeneration Facility, Massachusetts; IMC Global Inc. Soda Ash plant, California; CO2 storage in hydrocarbon reservoirs at the Great Plains Synfuels Plant; CO2 Capture and Compression, North Dakota.

[20] Solvent Absorption, Sumitomo Chemicals Plant, Chiba, Japan/Kokusai Carbon Dioxide, Chiba; Physical Absorption, Research on Physical Adsorption Method for CO2 Recovery, Yokosuka; Oil and Gas field of Teikoku Oil Co. in Nagaoka City, Niigata; CO2 Sequestration in Unminable Coal Seams in Japan, Micro Pilot Test: The Yubari Area, Ishikari Coal Basin, Hokkaido; and Deep Ocean Storage, Study of Environmental Assessment for CO2 Ocean Sequestration for Mitigation of Climate Change, Japan.

[21] One example is work going on at the into solvent absorption at the Luzhou Natural Gas Chemicals in Luzhou City.

Summary

There is an interesting blend of research capacities in the new technology areas among the members of the Climate Change Partnership.

Figure 1. Areas of significant research activity, by country

	Australia	**China**	**India**	**Japan**	**S.Korea**	**US**
Energy efficiency				●		W
Biomass		●	●			●
Nuclear				W	●	W
Wind						●
Solar		●	●	●		●
Hydrogen/Fuel cell	W			●	●	W
Carbon capture, storage	W			●	●	W

● indicates leading research, “W” indicates a world leader for research in field.

This suggests programs or streams in which members could collaborate across existing research activities.

Possible program streams for Partnership members

Global R& D programs with the members of the partnerships collaborating and leading based on existing programs could be built around the following clusters.

Program streams for collaboration in the Partnership				
Energy efficiency	China	Japan	USA	
Biomass	China	India	USA	
Nuclear	Japan	Korea	USA	
Wind	USA			
Solar	Australia	India	Japan	USA
Hydrogen/Fuel cell	Australia	Korea	USA	
Carbon capture, storage	Australia	Japan	Korea	USA

Widening the net

It would be an option for Partnership members to invite other countries to join these program research streams, contributing whatever they could afford. This would be an effective way of fostering access by other countries to these new technologies.

Under existing international arrangements on climate change, countries are to secure technology through participation in joint implementation, emissions trading, foreign investment in Clean development mechanisms and technical assistance such as through the Global Environment Fund.

The joint arrangements provided for under the Kyoto Protocol are not likely result in significant investment or transfer of technology. For these mechanisms to work, Kyoto needed to establish an enduring, global system. It has not. Instead it established a European-based system with four extra European members - Canada, Russia, Japan and New Zealand –with a short span of life.

The benefits provided under the Global Environment Fund are limited. Apart from the formidable task of trying to support activities in most developing countries, the focus of GEF has been limited to the more fashionable but less productive technologies such as photovoltaics and biomass. It has focused little on energy efficiency where perhaps the greatest gains in reducing emissions can be made the fastest, or other technologies which are already developed, like hydro and nuclear, again because they are not fashionable. [22]

Collaboration in partnerships where countries can contribute their own technological work, no matter how modest, in frameworks where the benefits can be shared, would be a much more practicable way of fostering global collaboration on climate change questions. The Asia Pacific Partnership on Clean Development and Climate is a golden opportunity to create such global mechanisms.

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[22] See Australian APEC Study Centre (2004) *The Kyoto Protocol and the APEC Economies*, 2003.

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