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Perspectives on international climate policy

Melanie Ford, Anna Matysek[a]*, Guy Jakeman, Andrew Gurney and Brian S. Fisher*
Australian Bureau of Agricultural and Resource Economics

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Current international frameworks including the Kyoto Protocol and the recently agreed Asia Pacific Partnership on Clean Development and Climate are examined in this paper along with their capacity to mitigate emissions growth. The Partnership shows potential to reduce growth in greenhouse gas emissions by stimulating the enhanced development and uptake of cleaner, more efficient technologies. However, decoupling of economic growth from energy consumption via the uptake of very advanced technologies will be required if atmospheric concentrations of greenhouse gases are to be stabilised at relatively low levels.

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[a]Contact author. Email: anna.matysek@abare.gov.au

abare | Tel +61 2 6272 2000 | GPO Box 1563 Canberra | Edmund Barton Building
www.abareconomics.com | Fax +61 2 6272 2001 | ACT 2601 Australia | Macquarie Street, Barton, ACT 2600

Introduction

Global population and economic activity are projected to expand in coming decades, particularly in developing countries as nations aspire to meet a variety of economic and social development goals. Assuming limited constraints on use, it is expected that fossil fuels will continue to supply much of the associated additional energy demands, leading to a rapid increase in global greenhouse gas emissions. Although considerable uncertainty exists about projected future levels of greenhouse gas emissions, the bulk of scientific opinion indicates that rising atmospheric greenhouse gas concentrations have the potential to induce climatic changes with associated environmental, economic, health and social impacts (Zillman 2005).

In response to increasing concerns about climate change, a number of international policy frameworks have been proposed and implemented. The Kyoto Protocol entered into force on February 16, 2005. The Protocol was negotiated under the United Nations Framework Convention on Climate Change. The Convention itself aims to reduce the atmospheric concentration of greenhouse gases to a level that would prevent “dangerous anthropogenic interference with the Earth’s climate system”. However, the potential emissions reductions achievable under the Kyoto Protocol appear limited, primarily due to a lack of emission reduction commitments in the rapidly growing developing countries. A complementary approach to the Kyoto Protocol is the recently signed Asia Pacific Partnership on Clean Development and Climate, which aims to promote the development, deployment and diffusion of cleaner, more efficient technologies.

In this paper, these international policy frameworks are considered in the context of their environmental effectiveness and other potential effects. Some perspectives on the characteristics of an appropriate international policy framework to address climate change are presented. This paper focuses on the crucial role of technology in greenhouse gas mitigation. However, it is also recognised that strategies and technologies that will enhance adaptation to climate change will also be required.

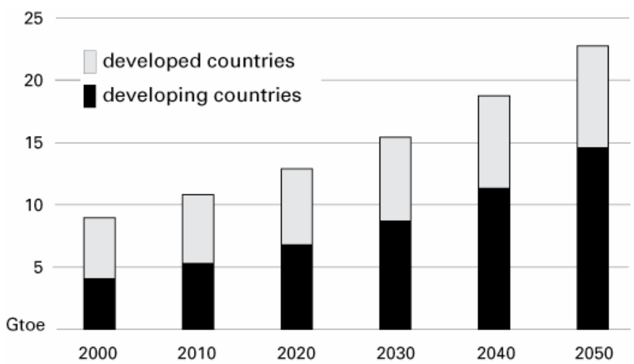
Energy demand: drivers and implications

Population growth is a significant determinant of total energy consumption both directly via its impacts on demand and also through its relationship to economic growth and development. The global population is projected to increase by about 42 per cent from 6.5 billion in 2001 to about 8.76 billion in 2050, reflecting strong growth in several developing regions including India and China. Demographic profiles vary significantly between regions reflecting different levels of economic growth, fertility, mortality, life expectancy and migration. Declining fertility rates in some regions such as Japan and parts of Europe mean their populations are projected to fall, whilst in India, relatively high fertility rates are projected to ensure a steadily growing population well into the future.

Real gross domestic product is projected to grow by about 340 per cent by mid century, reflecting a worldwide 3.1 per cent average annual growth rate. Developing countries are generally projected to experience relatively strong rates of GDP growth, underpinned by robust growth in labor supply and productivity.

As economies expand, so too do their demands for energy intensive goods and services such as electricity, transport, construction and manufactured goods. The rate of growth in energy consumption is projected to be lower in developed countries compared with developing countries as a result of lower population and economic growth rates and a transition away from energy intensive industries such as construction and manufacturing to less emissions intensive industries such as services. The net outcome on global energy consumption of these competing effects is a projected increase from about 9 Gtoe in 2001 to about 23 Gtoe in 2050 (figure 1).

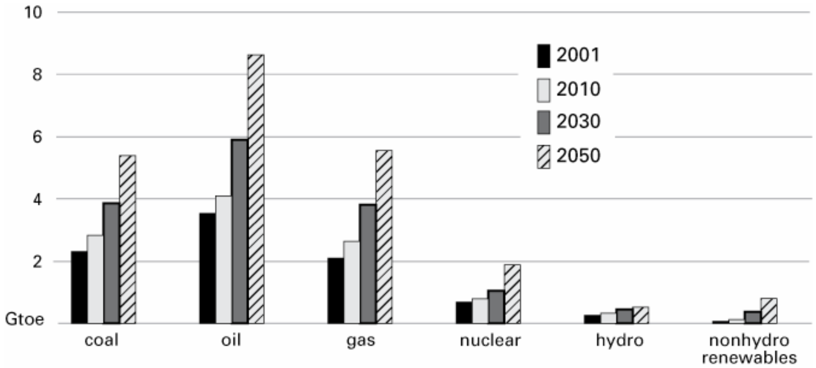
Figure 1: global primary energy consumption projections



Note: Does not include primary energy from nonhydro renewables that are not used in public and/or autoproducer electricity and heat production (for example, biomass used by private households).

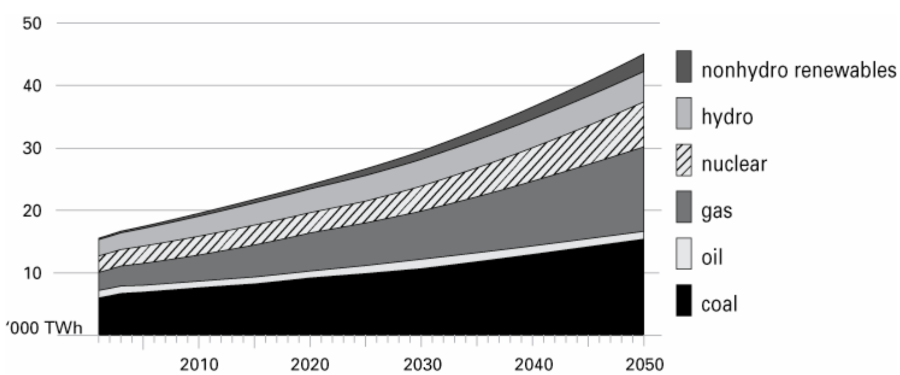
The composition of energy consumption varies between countries as a result of differences in domestic and regional energy reserves, current and expected fuel prices, industry composition, existing infrastructure, access to capital and resources, and energy security and environmental policies. At the global level, fossil fuels are projected to remain the dominant source of energy over the projection period, assuming no constraints on use (figure 2).

Figure 2: global primary energy consumption fuel mix



Global electricity demand increases by around 190 per cent over the projection period, reaching about 45000 TWh in 2050 (figure 3). Even though strong growth in nonhydro renewables is projected in the electricity sector, the contribution of these energy sources in the overall fuel mix remains small as a result of the greater economic viability of alternative energy sources, a low base year capacity and challenges to system integration and reliability.

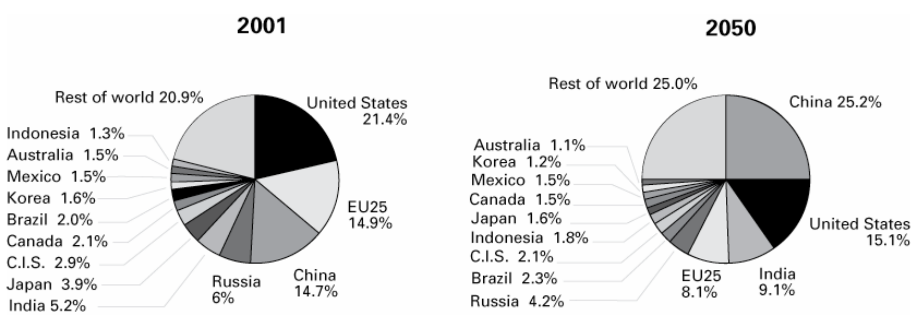
Figure 3: global electricity fuel mix



Assuming continued reliance on fossil fuels to meet projected increases in demand for energy, there will be a substantial increase in greenhouse gas emissions over the projection period. Assuming no change in current government climate policies, greenhouse gas emissions are projected to increase from 8.7 Gt C-e in 2001 to about 22.8 Gt C-e in 2050[1].

The contributions of selected regions to global greenhouse gas emissions are presented in figure 4. Emissions vary between regions as a result of differences in economic and sectoral development and organisation, resource endowments and the composition of production processes and technologies. Emissions growth is projected to be fastest in developing countries, particularly India and China, reflecting increases in population, economic activity and energy consumption. By around 2017, China is projected to overtake the United States as the largest contributor to global greenhouse gas emissions.

Figure 4: share of global greenhouse gas emissions for selected regions



Key sectors for emissions growth over the coming decades are electricity, transport, and energy intensive industry. Within the industrial sector, aluminium, cement, pulp and paper, mining and iron and steel are expected to be important contributors to emissions of greenhouse gases. Throughout this analysis these activities are referred to as key industries.

In 2001, electricity, transport, and key industries contributed about 30, 21 and 15 per cent of global greenhouse gas emissions respectively (figure 5). However, this sectoral composition of emissions will change over time. For example, the contribution of transport sector emissions to total emissions is projected to increase noticeably by 2050

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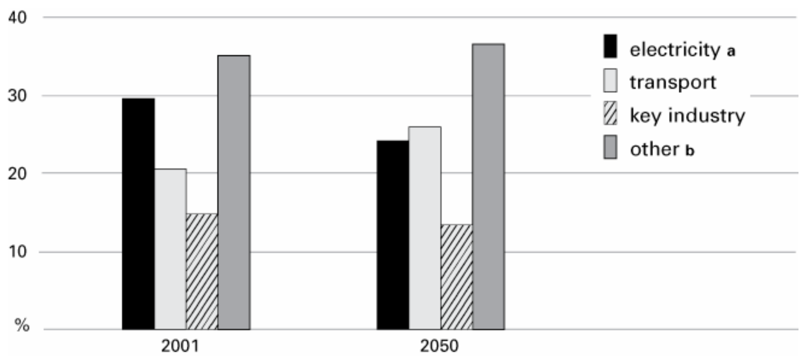
[1] Global emissions throughout the report include carbon dioxide (including from international bunkers), methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride. CFC emissions are excluded as these gases are not included under the Kyoto Protocol.

Greenhouse gas emissions are expressed in carbon dioxide equivalent terms, based on their global warming potentials over a 100 year time horizon as recommended by the Intergovernmental Panel on Climate Change (IPCC 1996).

in response to the growing demand for transport services by both private households and industry, particularly in developing countries. The emissions intensity of electricity is also expected to decrease at a faster rate than in transport, primarily as a result of greater potential improvements in electricity generation efficiency.

Figure 5: sectoral composition of global greenhouse gas emissions



Notes:

a Electricity emissions have not been allocated to end-users.

b Category includes emissions from petroleum products; chemicals, rubber and plastics; manufacturing; agriculture, forestry and fisheries; food; services; wastes; government consumption; industrial gases and private households (excluding emissions from petroleum consumption which are included in transport).

Current policy frameworks

Reflecting widespread concerns about climate change and potential impacts, a number of policies have been proposed. The Kyoto Protocol and the recently formed Asia Pacific Partnership on Clean Development and Climate represent two such international climate change policy frameworks that have been implemented.

UNFCCC and the Kyoto Protocol

At the Rio Earth Summit in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted. This agreement aims to reduce the atmospheric concentration of greenhouse gases to a level that would prevent dangerous anthropogenic interference with the Earth’s climate system. The great majority of national governments have chosen to become parties to the UNFCCC.

The Kyoto Protocol to the convention was adopted in 1997. The Protocol entered into force on February 16, 2005 after the Russian Federation’s ratification provided a necessary requirement for the Protocol to enter into force[1]. The Kyoto Protocol includes legally binding requirements for some participating industrialised countries (listed in Annex B to the Protocol), to limit their greenhouse gas emissions to an agreed percentage of their 1990 levels during the first commitment period of 2008 to 2012[2]. Non Annex B (developing) countries are not obliged to meet any emission reduction targets under the Kyoto Protocol.

To allow for flexibility in how countries meet their targets and to encourage more cost effective abatement actions, a number of flexibility mechanisms were included in the Protocol. The most important of these are: international emissions trading between (UNFCCC) Annex I nations; Joint Implementation which allows Annex I countries to receive emissions credits for investing in emission reducing activities in other Annex I countries; and the Clean Development Mechanism which allows Annex I countries to receive emissions credits by investing in emission reducing activities in non Annex I countries.

Although the Kyoto Protocol has been successful in raising international awareness of the potential challenges associated with climate change and has created a forum for the exchange of information and ideas, the Protocol is unlikely to achieve any substantial reduction in global greenhouse gas emissions. The rejection of the Protocol by the United States and Australia and the lack of emission reduction commitments for rapidly expanding developing nations seriously undermines its environmental effectiveness.

The focus on rigid emissions targets also makes the Protocol impractical as a long term policy mechanism, since the costs of reducing emissions are unknown, providing an incentive for Parties to negotiate less stringent targets as a condition for their continued participation. Developing countries are also unwilling to commit to binding targets that may limit their future growth, particularly given the considerable uncertainties surrounding the costs of binding emissions targets (McKibbin 2005).

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[1] This requirement was that 55 per cent of 1990 Annex I carbon dioxide emissions be covered by ratifying countries and that 55 parties to the Convention ratify the Protocol.

[2] Annex B countries were able to negotiate differentiated targets based on differences in their national circumstances. For example, Australia negotiated an emissions target of 108 per cent of 1990 levels while the European Community committed to an average 8 per cent reduction in emissions relative to 1990 levels. Within the Community differentiated targets have been established for individual member countries.

The complexity of the Protocol and the nature of United Nations (UN) negotiations have also hindered the effectiveness of the agreement. For example, the large number and diverse interests and agendas of Parties involved in the negotiations has meant that progress has been cumbersome and slow as a result of difficult logistics and political considerations (Fisher et al. 2004).

Given the current framework of the Protocol and the lack of emissions commitments for developing countries, it is difficult to envisage the negotiation of broader and/or more stringent targets for future Kyoto commitment periods.

The Asia Pacific Partnership on Clean Development and Climate

The Asia Pacific Partnership on Clean Development and Climate (APPCDC) consists of Australia, China, India, Japan, the Republic of Korea and the United States and was brought into effect on July 28, 2005. A key focus of the Partnership is to facilitate the development, diffusion, deployment and transfer of existing, emerging and longer term cost effective cleaner, more efficient technologies (APPCDC 2006a). The Partnership aims to address energy, air pollution and climate change issues within the context of continued economic development and poverty alleviation.

A key aim of the Partnership is to utilise expertise and experience in industry, research communities and governments in bringing cleaner technologies to market. Actions under the Partnership are anticipated to include technology based research, development and demonstration, exchange of information and expertise, dissemination of best practice technologies and provision of a forum for high level policy dialogue (APPCDC 2006b).

Partnership economies currently account for about 45 per of global population, 54 per cent of global economic output and 48 per cent of both global energy use and greenhouse gas emissions. The significance of the Partnership economies in global economic and energy markets means that actions by just six countries to develop and deploy low emissions technologies could substantially mitigate growth in future greenhouse gas emissions.

Principles for effective climate change policy

Policy frameworks for addressing the potential threats of human induced climate change in a manner consistent with economic growth and development should adhere to three fundamental principles: environmental effectiveness, economic efficiency and equity.

Environmental effectiveness - an environmentally effective policy must involve all major emitters to ensure that an appropriate environmental target can be achieved. Excluding any major emitters undermines the environmental effectiveness of abatement action by reducing the potential pool of abatement options and by increasing the burden on participating countries to achieve a given environmental goal.

Moreover, emitters that avoid abatement action may gain a competitive advantage by free-riding on the abatement efforts of other countries. This could induce movement of emission intensive industries to these countries from countries where emissions constraints do apply. This emissions leakage would at least partially offset abatement action undertaken elsewhere and increase the economic costs of participating in any emission reduction strategy.

Economic efficiency - economically efficient climate policies meet a given environmental objective at a lower cost than policies that are not. Technology will play a key role in achieving the most cost effective outcome.

Given the correlation between economic growth and energy use, a full suite of low emissions technologies, including nuclear power, carbon capture and storage and renewable energy will be required to allow countries to achieve their economic development, social, energy security and poverty alleviation goals while simultaneously addressing clean development and climate change concerns.

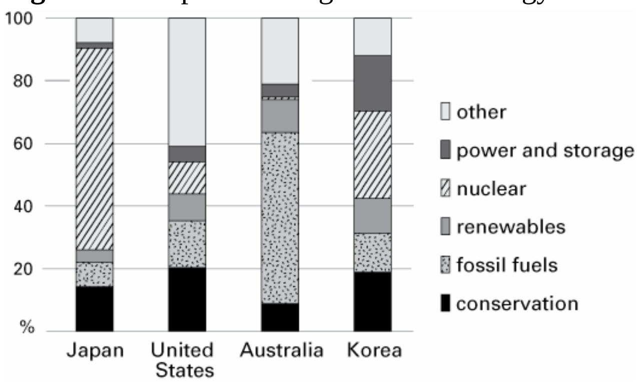
Although climate change is recognised as an important issue throughout the world, in most developing countries it is not considered an immediate priority for policy action. Economic, social development and poverty alleviation goals are more likely to take precedence in most developing countries in the short to medium term. As such, international policy frameworks that aim to engage developing countries on climate must allow the achievement of these goals while simultaneously encouraging reductions in emissions. A strategy promoting low emissions technologies that address energy security and air pollution issues and allow increased access to cheap, reliable energy provides a real incentive to developing countries' participation.

There are, however, a number of economic, political and technical barriers to the widespread development and uptake of low emissions technologies. National governments have a key role to play in establishing environments that are conducive to the development and transfer of low emissions technologies in both the public and private sectors. A portfolio of policy options that have an impact on both the demand and supply side are available, including research grants, emissions standards, tax incentives and emissions trading.

As the majority of energy sector research and development is performed in a limited number of OECD economies including Japan and the United States, the long term direction of the energy sector is being heavily influenced by the level of energy R&D in these countries and the composition of their research efforts.

The composition of energy R&D in selected economies is presented in figure 6. The importance of different fields in energy related R&D differs significantly between countries, and is a reflection of differences in current and projected energy mixes as well as strategic preferences. For example, public sector energy R&D in Japan and Australia focuses primarily on nuclear and fossil fuels respectively. In the United States, the importance of other energy technologies such as hydrogen has grown significantly in recent times.

Figure 6: composition of government energy research and development in 2002[a]



Source: IEA 2005
Notes: [a]2003 Australian data

A number of barriers exist to the widespread transfer and uptake of available technologies in developing countries, including trade restrictions, information barriers, incumbent human and fixed capital systems and weak intellectual property rights. Research and development efforts aimed at promoting cleaner, more energy efficient technologies should seek to identify actions to overcome these barriers through capacity building exercises, strengthening of intellectual property rights and removing impediments to trade and foreign investment.

Wide ranging R&D programs spread risk and potentially increase the economic efficiency of future abatement responses (assuming successful innovation) by providing greater potential for utilising low cost abatement opportunities across sectors and thereby reducing the overall cost of abatement.

Research and development on adaptation technologies and management strategies will also be an important component in achieving economic efficiency in the long run given that even immediate, severe emissions abatement would not avert some degree of global warming.

As climate change is a long term issue, economically efficient policy should encourage mitigation and adaptation over appropriate timeframes. Manne and Richels (1995) have demonstrated the additional economic costs associated with the premature retirement of fixed capital compared with a more efficient policy designed to achieve the same environmental outcome over a fixed time horizon without significant premature capital stock retirement.

Equity - the long term stability of any climate agreement will depend in part on perceptions about equity. Since the climate change problem transcends national boundaries, it requires an international response framework that is perceived as fair. As such, the strategy needs to be consistent with sustainable economic development and recognise that developing countries' energy consumption will need to grow over time to facilitate economic growth and development.

Facilitating technology transfer will assist in placing developing countries on a lower emissions trajectory than their developed country counterparts were at the same stage of economic development. However, despite the benefits of technology transfer from developed to developing countries, there are a number of impediments that must be overcome to enable equitable access to existing and new technologies.

International agreements also need a strong element of freewill and cooperation to be successful. Forcing countries to agree to mitigation activities is unlikely to prove successful in the long run and the threat of punishment for failure can reduce the incentive for participation.

Analysis of climate scenarios

To assess the possible impacts of the Kyoto Protocol and the Asia Pacific Partnership on Clean Development and Climate, ABARE's Global Trade and Environment Model (GTEM) was utilised. Reference case projections for key economic, energy and technology variables over the period to 2050 were developed. The reference case scenario aims to reflect a world in which technological development and government policies progress along likely pathways described in the projections literature, but in the absence of any significant changes to climate change policy. This enables an evaluation of the effect of alternative simulations in which policies and technological development deviate from current expectations. The impacts of assessed policies are generally presented as percentage changes from reference case levels. A full description of the

GTEM modeling framework and database used in this paper is available at www.abareconomics.com.

Scenarios

1. Partnership technology

The impacts of possible collaborative actions under the APPCDC were analysed by considering the accelerated development and transfer of more energy efficient technologies. Possible opportunities for action under the Partnership that could lead to increases in energy efficiency include greater R&D expenditure, the introduction of technology efficiency standards and/or efforts to increase capacity building and remove barriers to technology transfer.

In the Partnership technology scenario, collaborative action by Partnership economies from 2006 on technology is assumed to lead to an increase in the energy efficiency and uptake of cleaner technologies in electricity, transport and key industry sectors (aluminium, cement, mining, iron and steel, and pulp and paper products). Moderate energy efficiency improvements in other sectors within Partnership economies are also assumed, to reflect positive technological spillovers associated with technology development in the focus sectors. The gap between the energy efficiency levels of the most and least efficient economies is assumed to narrow in all sectors throughout the projection period. However, as a result of differences in access to capital, skilled labor and other inputs, complete energy efficiency convergence does not occur[1].

The technological development and diffusion goals identified in this scenario are assumed to be confined to Partnership economies to allow the impact of Partnership actions to be identified in isolation. This is a modeling assumption implemented for illustration purposes, since it is likely that other regions will enjoy positive spillovers from technological advances in Partnership countries through a range of mechanisms including trade, foreign direct investment, aid and mobile capital and labor markets.

2. Partnership technology + CCS

In this scenario, the same technology developments and transfer rates for electricity, transport and key industry sectors are assumed as in the Partnership technology

[1] See Fisher et al. (2006) for a description of potential low emissions technology options for the modeled sectors.

scenario. In addition, carbon capture and storage (CCS) technologies are assumed to be utilised in all new coal and gas fired electricity generation plant from 2015 in the United States, Australia and Japan and from 2020 in China, India and the Republic of Korea. The utilisation of carbon capture and storage technologies is assumed in order to give an indication of the potential carbon dioxide emissions reductions that might be possible under a CCS focused technology protocol. This scenario should be interpreted as illustrative rather than policy prescriptive.

The cost of nonhydro renewable electricity technologies are also assumed to decline over the projection period such that they are 20 per cent lower in 2050 relative to reference case levels. This is assumed to be a result of successful collaborative action on R&D and cost reducing learning by doing effects.

3. Global technology + partnership CCS

The development and availability of more energy efficient technologies in the electricity, transport and key industry sectors are assumed to diffuse throughout the world in this scenario. However, as a result of the cost premium associated with CCS such technologies are assumed to be adopted only in Partnership economies under the same assumptions as scenario 2.

4. Kyoto forever

It is assumed that all ratified Annex B parties comply with their first commitment period Kyoto emission targets. Parties' participation and emissions targets in the second and subsequent commitment periods are assumed to remain the same. For example, Canada is committed to reducing its emissions over the period 2008-12 to 94 per cent of its 1990 levels. This target is then held constant over the entire projection period to 2050.

The Kyoto forever scenario therefore represents a highly optimistic extension of the current Kyoto framework. It is considered unlikely that Parties would agree to such stringent emissions targets in coming negotiations given the uncertainty in costs of abatement and the likely rejection of targets by developing countries. However, the scenario was adopted to illustrate the potential outcomes from an extension of the Kyoto framework.

The cost of meeting Annex B abatement commitments depends to a large degree on access to the Kyoto flexibility mechanisms, such as international emissions trading. Unrestricted international emissions trading allows more abatement to be undertaken in regions where the marginal cost of abatement (at the given quota allocation) is lowest.

There will be no incentive for further trade in quota once the marginal abatement cost from each emissions source is equal to the price of the quota. At this point, the cost of participating Annex B abatement will be minimised, ignoring the effect of transaction costs and the feedback effects of emissions trading on other taxes and distortions in the economy.

Box 1: Modeling the Kyoto forever scenario

In GTEM, modeling international emissions trading requires the aggregate emissions of participating regions to be constrained to their emission reduction commitments under the Kyoto Protocol and in subsequent commitment periods. The model determines a uniform carbon equivalent penalty across participating Annex B regions (equivalent to the price of an internationally traded emission quota) sufficient to meet the aggregate emission target. The initial Kyoto commitments represent an initial allocation of obligations, or emission quota, among the participating countries. Income from the sale of emission quota is accounted for as foreign income transfers and added to gross national product, while payments for purchases is subtracted from gross national product.

Banking of emission quota is permitted under Article 3.13 of the Kyoto Protocol, which allows Parties whose emissions are below their emissions target in one commitment period to carry their unused quota over to the next commitment period.

In equilibrium, the quota price satisfies the intertemporal arbitrage condition derived by Hotelling (1931). In the context of quota banking, the condition has been derived in Hinchy et al. (1998) and leads to the present value of the emissions quota price being equalised over time. A real discount rate of 7 per cent a year — consistent with the average Annex B rate of interest in the GTEM reference case — was assumed.

Results

Energy consumption

Under both the Kyoto forever and global technology + partnership CCS scenarios, total energy consumption is reduced relative to the reference case (figure 7). Under the Kyoto forever scenario, the imposition of a constraint on the emissions of participating Annex B nations results in a reduction in total energy consumption, relative to the reference case, as participants respond to the higher cost associated with emissions in part by reducing output and in part by increasing the energy efficiency of production technologies.

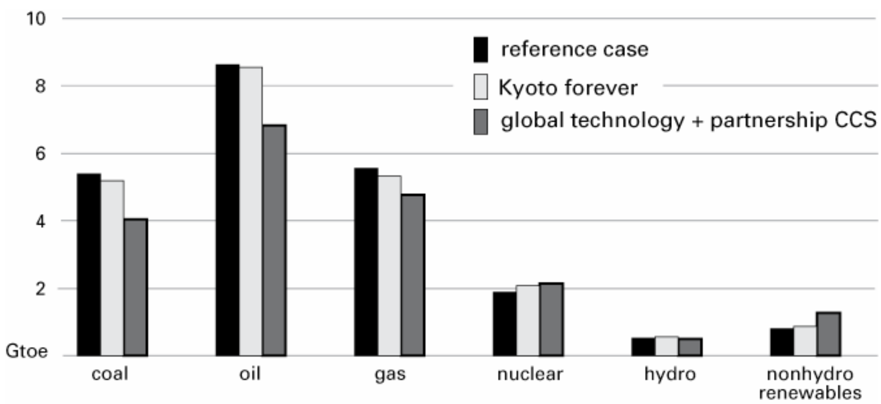
The adoption of more energy efficient technologies and the increased costs of electricity production associated with carbon capture and storage technologies in the global technology + partnership CCS scenario also results in a reduction in global energy consumption, relative to the reference case.

The gap between reference case energy consumption and consumption under the analysed scenarios increases throughout the projection period due to the increasing stringency of the emissions target under Kyoto forever and the accelerating adoption of energy efficient technologies and carbon capture and storage under the global technology + partnership CCS scenario.

Under both scenarios, the consumption of fossils fuels is reduced relative to reference case levels. In the Kyoto Forever scenario, participating Annex B countries respond to emissions constraints by reducing energy consumption and increasing adoption of less carbon intensive fuels such as nuclear and renewables.

In the global technology + partnership CCS scenario, the adoption of more energy efficient technologies and the higher cost of electricity following adoption of CCS technologies lowers consumption of fossil fuels relative to reference case levels. Utilisation of nuclear and nonhydro renewable technologies increases relative to the reference case under the global technology + partnership CCS scenario as electricity producers switch toward these energy sources in response to higher electricity generation prices for coal and gas fitted with CCS.

Figure 7: global primary energy consumption by fuel mix, 2050

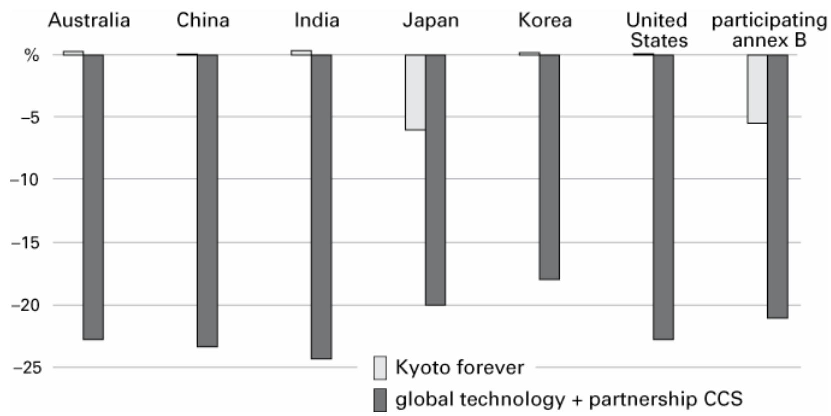


Energy security

Under the Kyoto forever scenario, global oil consumption is reduced only marginally in 2050 relative to the reference case. The reduction in oil consumption by participating Annex B countries in response to an emissions constraint is partially offset by an increase in oil consumption in other countries as the decreased consumption in Annex B economies marginally reduces the world oil price (figure 8).

In the global technology + partnership CCS scenario, the reduction in oil and other fossil fuel consumption relative to the reference case and the transition to nuclear and nonhydro renewables has important implications for energy security. In China and India, oil consumption is reduced by about 23 and 24 per cent respectively in 2050, relative to the reference case. The reduction in oil consumption in the global technology + partnership CCS scenario differs moderately between regions as a result of differences in assumed energy efficiency improvements and substitutability between fuels.

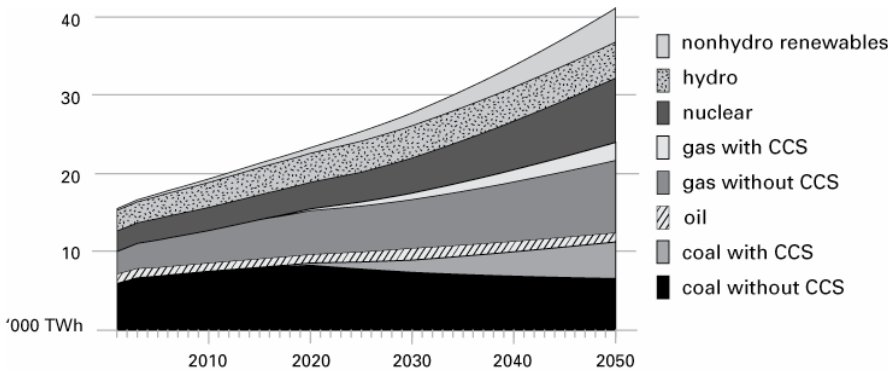
Figure 8: change in oil consumption in 2050, relative to reference case



Electricity fuel mix

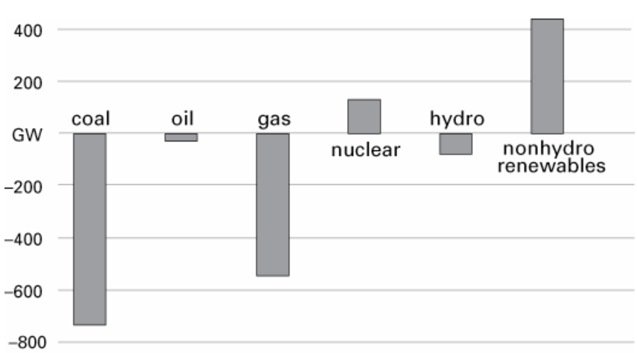
The adoption of more fuel efficient electricity generation technologies and an increase in the price of coal and gas fired generation following the forced introduction of CCS technologies reduces global electricity demand under the global technology + partnership CCS scenario, in relation to the reference case (figure 9).

Figure 9: global electricity fuel mix: global technology + partnership CCS



The reduction in electricity demand in the scenarios analysed in this paper reduces the overall demand for global generation capacity relative to the reference case. That is, the reduction in electricity demand in the global technology + partnership CCS scenario reduces requirements for new coal and gas fired generation capacity by about 734GW and 555GW respectively between 2001 and 2050. However, the increase in the cost of coal and gas fired electricity associated with deployment of CCS technologies raises the required generation capacity from nuclear and nonhydro renewable energy sources by 130GW and 440GW respectively (figure 10).

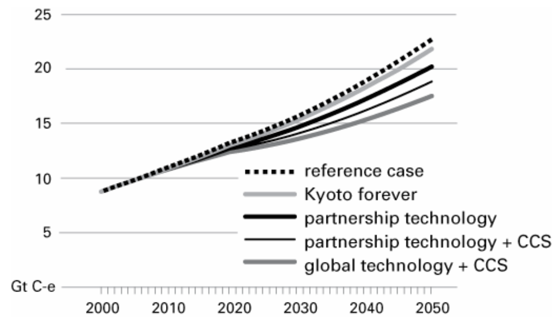
Figure 10: change in electricity capacity, global technology + partnership CCS scenario, relative to reference case, 2001-50



Greenhouse gas emissions

Global greenhouse gas emissions in the reference case are projected to increase by about 160 per cent over the period 2001-2050. Although action to address climate change is projected to reduce the growth in total greenhouse gas emissions, they will rise well above 2001 levels over the projection period in each of the scenarios investigated in this paper (figure 11).

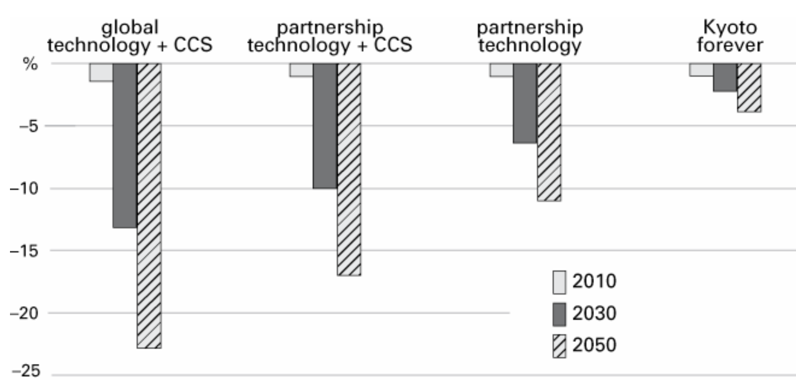
Figure 11: global greenhouse gas emissions



The level of emissions reductions relative to the reference case increases through time in the Kyoto forever scenario. This occurs as the emissions target becomes more stringent against the projected increase in reference case emissions in participating Annex B nations (figure 12). Under the Kyoto forever scenario, global greenhouse gas emissions are reduced by about 1 per cent in 2010, relative to the reference case. By 2050, global greenhouse gas emissions are about 4 per cent lower than reference case levels. Emissions abatement under the Kyoto forever scenario is severely constrained by the lack of developing country participation, since developing countries are responsible for about 70 per cent of global greenhouse gas emissions by 2050.

The level of emissions abatement relative to the reference case also increases over time in the enhanced technology scenarios, as the level of adoption and diffusion of cleaner technologies escalates. In the global technology + partnership CCS scenario, the worldwide diffusion and transfer of more energy efficient technologies and the use of CCS in Partnership countries leads to a global reduction in emissions of about 23 per cent in 2050, relative to the reference case.

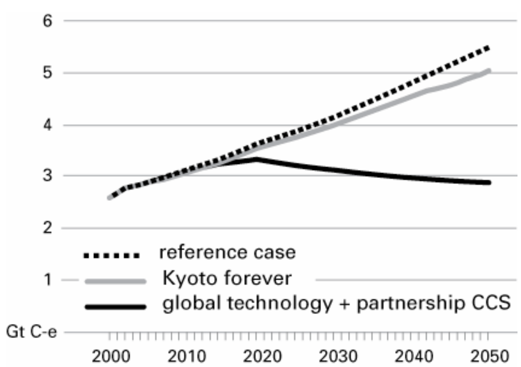
Figure 12: change in global greenhouse gas emissions, relative to reference case



Global electricity emissions are projected to grow on average at about 1.5 per cent a year over the projection period in the reference case. In the Kyoto forever scenario, growth in global electricity emissions is moderately mitigated as participating Annex B nations reduce electricity consumption and switch toward less carbon intensive fuels. In 2050, global electricity emissions under the Kyoto forever scenario are about 8 per cent lower than in the reference case (figure 13).

The utilisation of CCS technologies on all new coal and gas fired electricity generation plant in Partnership countries significantly reduces the growth in global electricity emissions under the global technology + partnership CCS scenario. Global electricity emissions under the global technology + partnership CCS scenario are about 47 per cent lower in 2050 than what they would otherwise have been. Electricity emissions in Partnership economies continue to increase to about 2021, at which point the capture and storage of emissions results in an absolute decline in Partnership emissions from electricity generation. This reduction brings global electricity emissions at 2050 back to around present day levels.

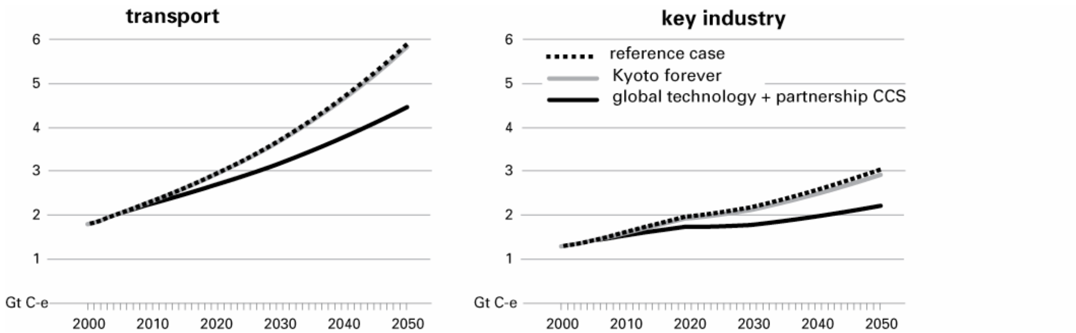
Figure 13: global electricity emissions



Global transport and key industry emissions are projected to grow on average by about 2.5 and 1.8 per cent per year respectively in the reference case over the period 2001-50. In the Kyoto forever scenario, emissions from both the transport and key industry sectors stay close to reference case levels (figure 14), indicating that abatement in these sectors is relatively small and that total abatement actions are also limited. For example, in 2050, global transport and key industry emissions are reduced by about 1 per cent and 4 per cent respectively, relative to the reference case.

In the global technology + partnership CCS scenario, emissions from both the transport and key industry sectors are reduced significantly compared with the reference case as more fuel efficient technologies are taken up in these sectors (figure 14). In this scenario, global transport and key industry emissions are about 24 and 27 per cent lower in 2050 respectively than what they would otherwise have been.

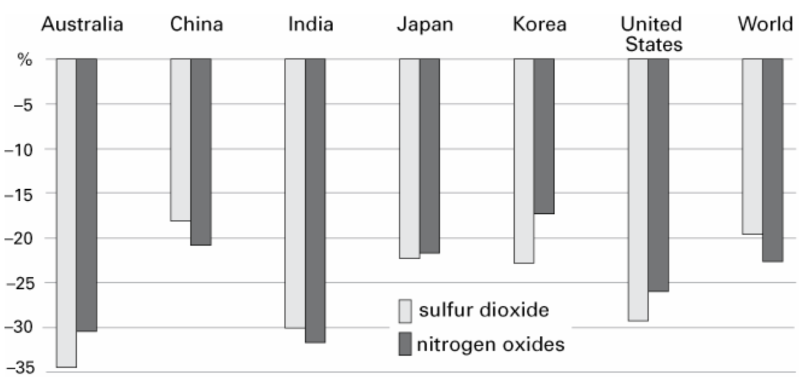
Figure 14: global transport and key industry emissions



Emissions of sulfur dioxide and nitrogen oxides can occur when fossil fuels are combusted in power plants, vehicles, industrial activities and home heating and cooking. These emissions are important sources of local air pollution in many large cities, particularly in developing countries, and have been linked to premature death and the increased incidence of respiratory and other health disorders (NREL 2001; Gielen and Changhong, 2001).

Emissions of sulfur dioxide and nitrogen oxides are reduced in the global technology + partnership CCS scenario (relative to the reference case) as demand for fossil fuels decreases in response to improvements in energy efficiency, fuel switching and reduced output (figure 15).

Figure 15: change in emissions of sulfur dioxide and nitrogen oxides in global technology + partnership CCS scenario at 2050, relative to reference case



Sources of abatement

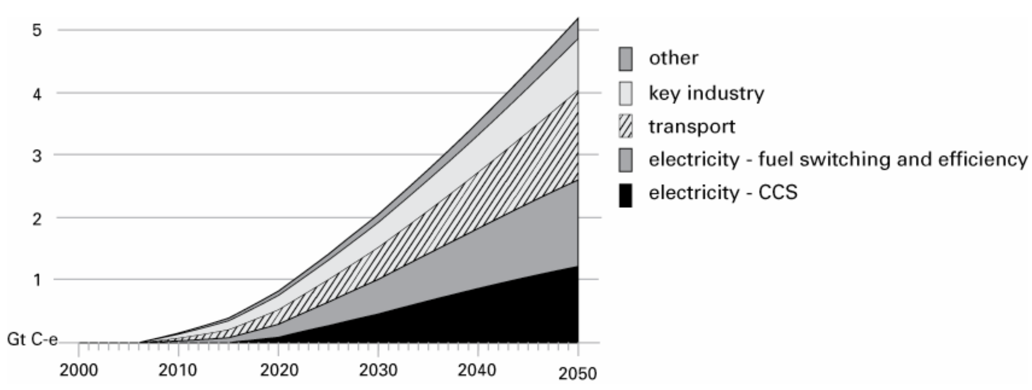
In the global technology + partnership CCS scenario, actions to develop more energy efficient and low emissions technologies in the electricity, transport and key energy intensive industries and the diffusion of these technologies to other regions results in a cumulative reduction in global emissions over the projection period of more than 90 Gt C-e, relative to the reference case (figure 16).

The development and uptake of more advanced electricity generation technologies and a significant transition to other low emissions electricity sources such as nuclear and nonhydro renewables, provide the largest contributions to cumulative abatement over the projection period, with about 27 per cent of total abatement. The widespread uptake of more fuel efficient vehicle technologies is also a significant contributor to global emissions abatement, accounting for about 26 per cent of total cumulative abatement over the period. Carbon capture and storage technologies in Partnership economies provide about 22 per cent of the emission reductions over the period.

Improvements in energy efficiency in key industry sectors and efforts to reduce fugitive emissions from mining and aluminium account for about 18 per cent of global abatement over the period. Improvements in energy efficiency in other sectors accounts for about 6 per cent of cumulative abatement over the period.

The significant contributions to abatement from a range of technologies and actions in different sectors demonstrates that a wide range of abatement options are utilised throughout the economy in achieving these substantial emissions reductions. However, even with the widespread uptake of more fuel efficient and lower emissions technologies in electricity generation, transport and key industry, emissions continue to grow throughout the period.

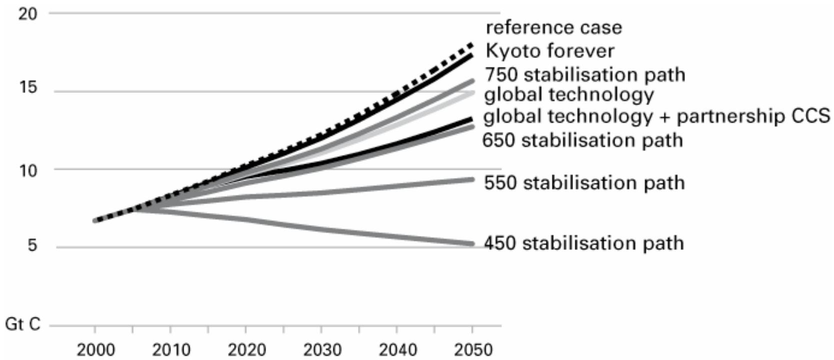
Figure 16: sources of abatement: global technology + partnership CCS



The carbon dioxide emission concentration pathways for the reference case, Kyoto forever and the global technology + partnership CCS scenarios are illustrated in figure 17 along with illustrative pathways for stabilising the atmospheric concentration of carbon dioxide at various levels. These pathways are consistent with achieving stabilisation of the atmospheric concentration of carbon dioxide at around 2100 and imply a reduction in the level of emissions beyond the 2050 projection period in order to achieve these targets. These emissions stabilisation paths are illustrative only – there are an infinite number of possible pathways consistent with stabilisation at a given atmospheric concentration.

A comparison of the emission concentration pathways associated with the analysed scenarios and the stabilisation pathways shown in figure 17 indicates that the global technology + partnership CCS scenario follows a path similar to the illustrated 650ppm stabilisation pathway. Both the reference case and the Kyoto forever scenarios follow an emissions path well above that of the 750ppm stabilisation pathway.

Figure 17: atmospheric carbon dioxide concentration pathways and scenarios



Given the substantial technical change built into the scenarios represented in this paper, placing the global emissions trajectory on a pathway consistent with stabilisation of atmospheric carbon dioxide at or below around 650ppm in 2100 would be a difficult task. It would require expanding the portfolio of implemented technologies to additional sectors and activities, as well as extensive and widespread implementation of more highly advanced technology options. Large scale, widespread deployment of low and zero emissions technologies that enable the decoupling of emissions from economic growth would be required, greatly exceeding the degree of technological deployment considered in this paper. The scale of technology deployment that would be required to achieve low stabilisation levels would require major policy interventions entailing significant costs to the global economy that would need to be considered against averted damages, while taking into account possible adaptive measures..

Given the implications of this result with respect to possible temperature change, the result is also strongly indicative of the need for focusing additional effort on adaptation technologies and strategies, however these aspects are beyond the scope of this paper.

Concluding comments

Greenhouse gas emissions are expected to increase substantially by mid century given projected increases in global population and economic activity and continued reliance on fossil fuels to meet energy demands for some time into the future.

To be environmentally effective, any policy framework that aims to address climate change must involve major emitters, including the rapidly growing developing countries. However, for most developing countries, climate change is a secondary priority to more immediate concerns about poverty alleviation and economic development. As such, engaging developing countries on the climate issue is politically challenging and must be undertaken in the context of recognising the importance of developmental goals while simultaneously encouraging reductions in emissions.

Technology will be crucial to achieving significant mitigation in emissions growth while simultaneously allowing countries to pursue improvements in energy security, reductions in air pollution and attainment of economic and social development goals. Governments have a key role to play in establishing environments that are conducive to the development and transfer of low emissions technologies. A portfolio of policy approaches including funding for research and development, the introduction of technology standards and efforts to improve capacity building and technology transfer will be necessary to encourage the uptake of both mitigation and adaptation technologies. Collaborative efforts between government, industry and other stakeholders on research and development should be aimed at identifying barriers to technology development, adoption and transfer and at finding solutions to improve the performance, cost, safety and environmental acceptability of low emission technologies.

The Asia Pacific Partnership on Clean Development and Climate offers strong potential to enhance the development, deployment and diffusion of energy efficient technologies throughout Partnership countries and to generate positive technological spillovers to the rest of the world via trade and foreign direct investment. The inclusion of major current and future emitters representing a range of countries at different stages of development and with different resource endowments is advantageous in the sense that a range of technologies will need to be considered for development.

The voluntary nature of the Partnership and inclusion of a range of environmental and social goals in the Partnership's charter including energy access, air pollution reduction and climate change mitigation also enhances its membership appeal, particularly to developing countries that are increasingly facing such issues.

There is real potential under the Asia Pacific Partnership to achieve significant reductions in growth of global greenhouse gas emissions. In this paper, several scenarios were modeled to investigate the potential emissions reductions that could be achieved, relative to what would have otherwise occurred, under possible Partnership actions. The emissions impacts from extending the transfer and adoption of more energy efficient technologies to the global scale were examined along with the accelerated deployment of CCS technologies. The emissions effects of an extended Kyoto style policy framework were also analysed.

While international awareness of climate change has been heightened, and a range of non-binding actions for measuring and reporting emissions have been developed and promoted as a result of the Kyoto Protocol, the large number of Kyoto parties not subject to mutual emissions constraints severely hampers the Protocol’s potential to achieve efficient, equitable or environmentally effective outcomes. It is apparent from the modeling results that even an extended Kyoto style policy framework would do little to curb global greenhouse gas emissions or to move toward stabilising the atmospheric concentration of these gases.

The Asia Pacific Partnership, which offers a complementary approach to Kyoto, captures around 50 per cent of global population, GDP, energy consumption and emissions by way of just six members. While negotiations will certainly be less cumbersome in such a setting and there are real incentives for countries such as China and India to participate and remain within the voluntary Partnership, most emissions savings will not be generated for some time, since there are lead times in technology development and diffusion. Initially, countries under the Partnership will aim to move toward the existing efficiency frontier, while aspiring via successful research and development to generate even cleaner and more efficient technologies for later deployment.

Although the modeled Partnership actions included significant energy efficiency improvements for the sectors considered, global emissions under all of the enhanced technology scenarios continued to grow strongly into the future. Even the weighty deployment of carbon capture technologies on all new coal and gas fired electricity generation capacity within the next 10 to 15 years could not turn the upward emissions trajectory. Moreover, the mitigation achieved under the enhanced technology scenarios in this paper were based on assumptions regarding the more rapid development and uptake of advanced technologies, which will only be possible if Partnership countries exert considerable additional effort, over and above existing efforts, to develop and transfer advanced technologies.

While the technology focused approach certainly has much greater potential to mitigate emissions growth in comparison to the Kyoto style approach, it is evident that achieving atmospheric carbon dioxide stabilisation levels below 650ppm would be a difficult task. Massive deployment of low and zero emissions technologies would be required, greatly exceeding the degree of technological deployment considered in this paper. Considering the substantial technical change built into the scenarios represented here, it would be necessary to expand the portfolio of technologies across additional sectors and activities, as well as to consider more advanced technology options that allow for the complete decoupling of carbon emissions from economic growth. Engendering this degree of technological change would require major policy interventions and entail costs to the global economy that would need to be considered against averted damages, while taking into account possible adaptive measures.

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