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Energy demand in the new millennium

Outlook and issues

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The objective in this paper is to discuss the outlook for world energy demand to the year 2010. The paper includes a reference case in which the outlook for key energy variables is presented. This takes account of the key determinants of energy demand on a 'business as usual' basis in the absence of specific new policy initiatives. The energy sector impacts of climate change response policies, trade liberalisation initiatives and domestic energy sector deregulation are discussed, based on current research at ABARE.

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Introduction

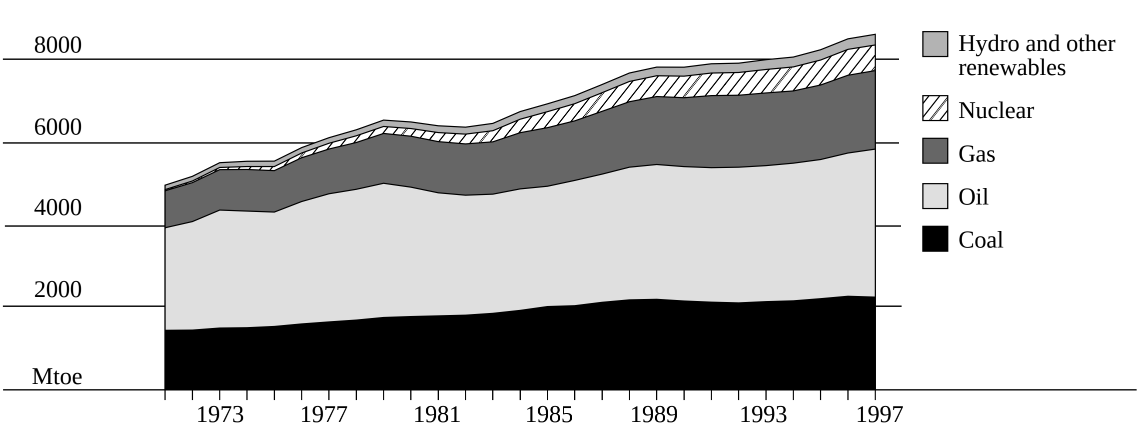
International policy responses to the threat of global climate change and the implementation of multilateral trade liberalisation initiatives are two factors that have the potential to influence the level, fuel mix and geographic pattern of world energy demand into the new millennium. These policy factors add to a range of uncertainties that surround the long-term outlook for world energy demand, including economic growth, population growth, consumer behavior, technological change, including the emergence of the information economy, and domestic energy sector reform.

International policy responses to meet the greenhouse gas abatement targets established in the Kyoto Protocol are likely to reduce the global demand for fossil fuels, particularly coal. In contrast, the liberalisation of international trade regimes is expected to lead to higher real incomes in most economies and, in the absence of other changes such as accelerated energy efficiency improvements, to increased consumption of energy. Trade liberalisation is also likely to alter the geographic pattern and fuel mix of world energy trade. At the individual economy level energy sector reform, including deregulation of electricity supply industries, will be an important driver of the level and composition of energy demand.

Historical world energy consumption

World energy consumption increased at an average annual rate of 2.1 per cent from 1971 to 1997 (figure 1) driven by growth in real gross domestic product (GDP) of 2.9 per cent a year. As a result, world energy intensity, or the ratio of world energy consumption to GDP, declined. This mainly reflected decreasing energy intensity in OECD countries in response to the 1970s oil price shocks, the consequential implementation of energy efficiency policies and a shift in the structure of economic output toward less energy inten-

Figure 1: **World energy consumption, by fuel**
Million tonnes of oil equivalent



Source: IEA (1998a,b).

sive service industries such as the business and financial sectors (International Energy Agency 1998). These trends in OECD countries outweighed the growing energy intensity of GDP in a number of developing economies that are in the process of industrialisation.

World population growth over the period averaged 1.7 per cent a year resulting in increased per person energy consumption. While population growth was higher in developing countries, so was the growth in energy consumption, particularly in the newly industrialised and developing countries of Asia. This reflects the increased personal use of energy services such as transport, electricity and heat that occurs with rising per person incomes. Despite increasing energy consumption in developing economies there remain wide disparities in per person consumption between countries.

Fossil fuels dominated global energy consumption from 1971 to 1997 and accounted for almost 90 per cent of world energy consumption in 1997 (figure 1). Oil continues to account for the largest share of energy consumption and is used mainly for transport as well as heating, industrial processes and power. However growth in oil consumption over the period was the lowest of all fuels at only 1.4 per cent a year. This mainly reflects the slow or negative growth of oil consumption in nontransport sectors in OECD countries because of the lower short term marginal cost of other fuels (International Energy Agency 1998c). In addition, energy security concerns led many countries to adopt policies to diversify energy consumption away from oil.

The consumption of coal and gas grew more rapidly than oil between 1971 and 1997, mainly for use in power generation. This was particularly the case in developing countries where demand for electricity increased rapidly with economic growth, population growth and rising per person incomes. Consumption of nonfossil fuels was dominated by nuclear energy and hydro power, with minimal use of other renewables such as geothermal, solar and wind.

Projecting world energy consumption

Projections of world energy consumption presented in this paper are based on applications of ABARE's Global Trade and Environment Model (GTEM). GTEM is a dynamic general equilibrium model of the world economy developed to address global change policy issues. It is derived from the MEGABARE model (ABARE 1996) and the GTAP model (Hertel 1997). The model features detailed treatment of energy and energy related sectors, includes the three principal greenhouse gases in the Kyoto Protocol (carbon dioxide, methane and nitrous oxide), and has an extensive representation of measures that distort international trade. The model code can be accessed on ABARE's web site (www.abareconomics.com).

In GTEM a reference case, or business as usual simulation, provides a basis against which the impacts of a policy change can be measured. The reference case projects the growth in key variables in each region in the absence of any policy changes. In this paper the reference case represents the likely outlook for world energy consumption in the absence of any new responses to global climate change or the implementation of multilateral trade liberalisation policies. It also does not include the impacts of domestic energy sector reform beyond those already in place. The reference case projections in this paper are based on ABARE's work in the context of climate change policy (Polidano et al. 2000).

In the reference case world GDP growth is assumed to average 3.1 per cent a year from 1995 to 2010. This takes account of the effects of the Asian economic downturn and is based on the assumption that per worker GDP in all countries will converge toward that of the United States in the very long term. Over the period 1995–2010, GDP in China, other Asia and the rest of the world is projected to grow at average annual rates of 6.9, 5.3 and 4.1 per cent respectively. This compares with 2.6 per cent in developed economies and 2.8 per cent in the economies in transition, comprising the former Soviet Union and central and eastern Europe. Developing economies tend to grow at higher rates because of typically more rapid increases in population, productivity and investment compared with developed countries.

World population is projected to grow at an average annual rate of 1 per cent over the projection period. The estimates of country specific fertility and mortality rates in GTEM are inversely related to per person incomes. As developing countries generally have lower per person incomes than developed countries, population growth rates are projected to be higher in developing countries. In aggregate, population in the developing countries increases at an average annual rate of 1.3 per cent compared with 0.3 per cent in the developed countries, while population in the economies in transition declines at an average annual rate of 0.1 per cent.

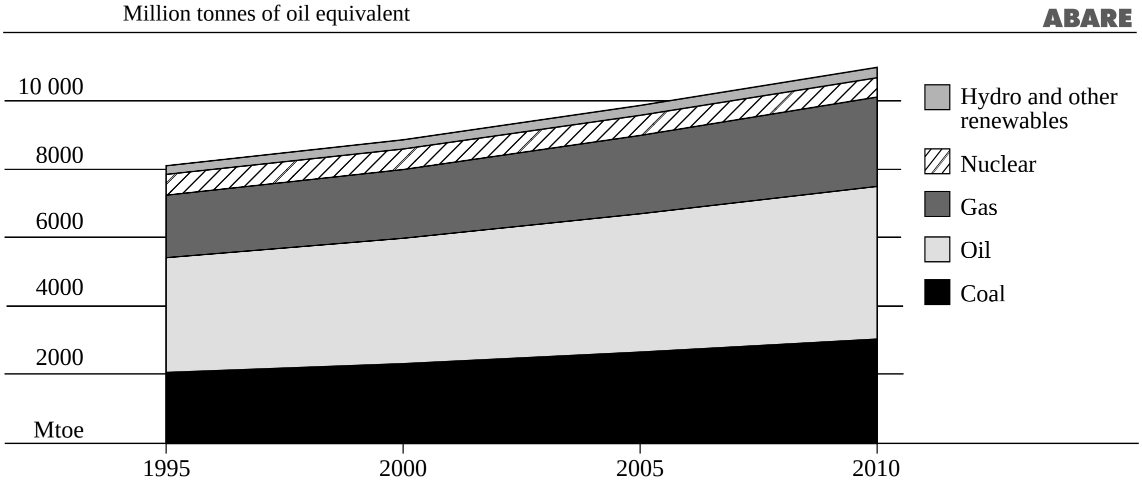
Productivity and investment growth are on average projected to be highest in developing countries. This is because of greater potential for technological catch up and generally higher returns to investment in low income economies.

Reference case projections of world energy consumption

World demand for energy is projected to grow at an average annual rate of 2 per cent over the reference case period (figure 2).

Oil is projected to continue to satisfy the largest share of energy demand (41 per cent by 2010) and is driven mainly by continued strong demand for transport fuels in both developed and developing economies (figure 3). Growth in oil demand remains closely linked to GDP growth, reflecting limited fuel substitution possibilities, especially in the transport sector.

Figure 2: **World energy consumption, by fuel, reference case**
Million tonnes of oil equivalent



Coal is projected to remain the second most important primary fuel source, accounting for 28 per cent of world energy demand in 2010. World demand for coal grows rapidly, underpinned by strong growth in the power generation sector in developing countries. Aggregate coal demand growth in the developed countries and economies in transition is negligible as a result of the falling share of coal fired power generation in Europe and the former Soviet Union.

Gas demand in each region is projected to increase more rapidly than other fossil fuels over the reference case period. This reflects the rapid increase in gas fired power generation, especially in developed countries where gas often has a competitive advantage over other fuels. However, growth in total gas consumption is likely to be constrained by the saturation of gas demand in other sectors in developed countries, for example for space and water heating in the residential sector. Also, large low cost reserves of coal in some developing countries such as China and India limit the use of gas for power generation in

Figure 3: **Average annual growth in fossil fuel consumption, 1995–2010, reference case**

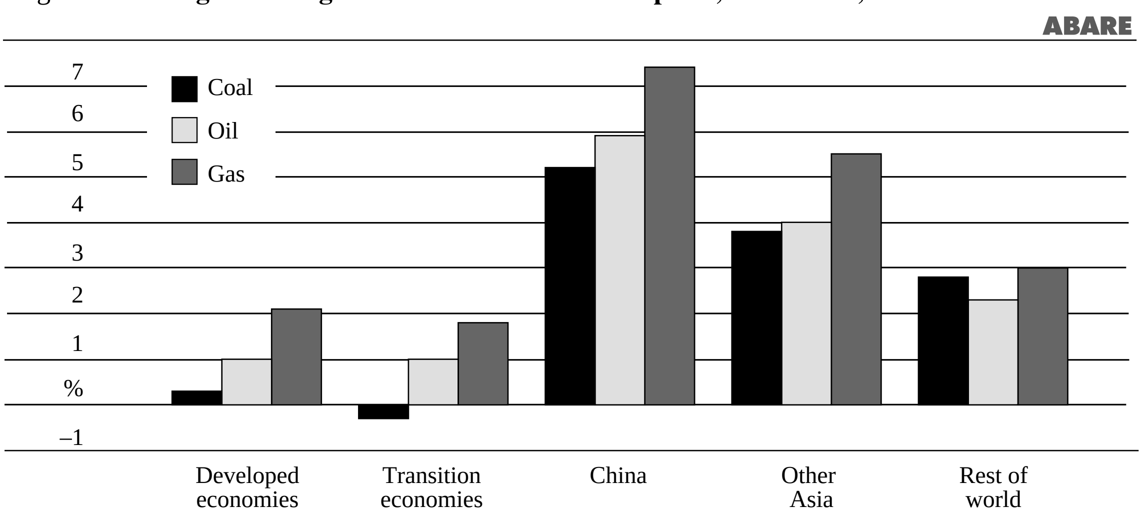
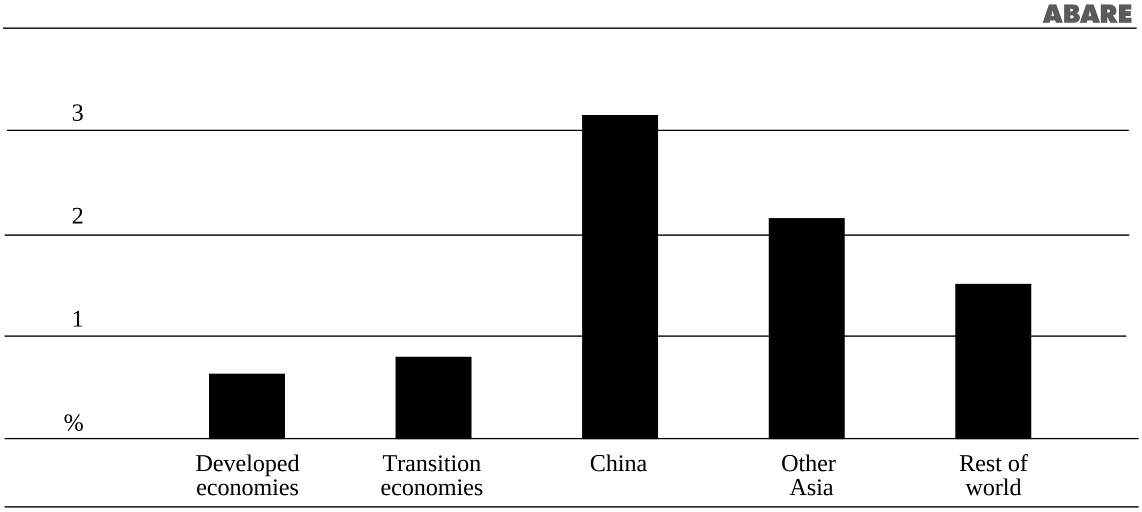


Figure 4: **Average annual growth in electricity generation, 1995–2010, reference case**



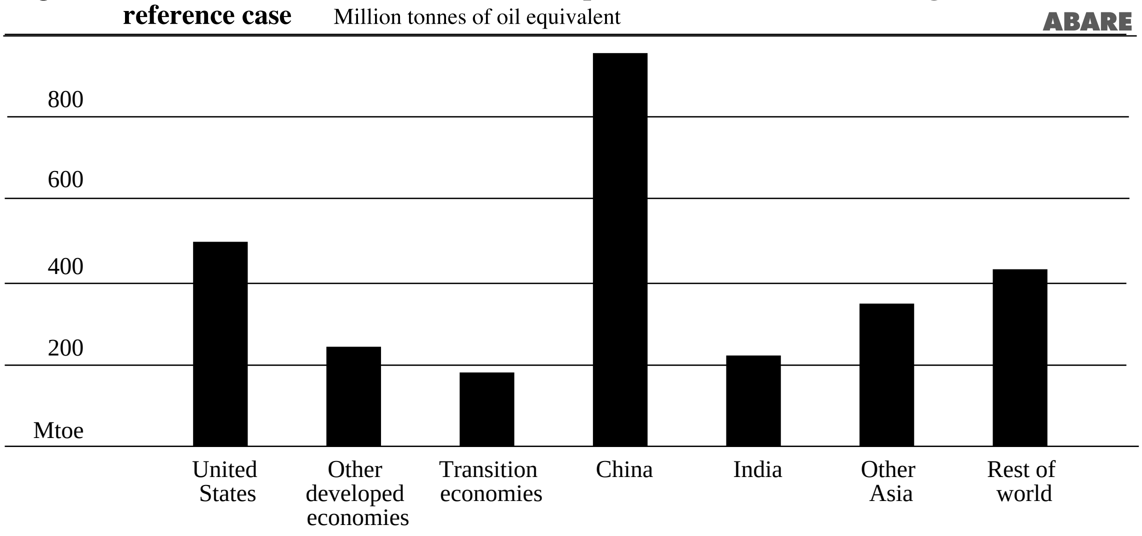
these regions. In addition, it is assumed that the demand for gas in the manufacturing sector will be moderated by improved end use efficiencies.

Most of the absolute growth in world demand for fossil fuels between 1995 and 2010 occurs in developing countries (figure 4), reflecting strong growth in economic output, high population growth and increased consumption of energy services (such as transport, space heating and electrical appliances) that accompany rising per person incomes. China dominates the outlook for world energy demand over the period, accounting for 34 per cent of the projected increase in world energy consumption and 49 per cent of the increase in developing country energy consumption. It should be noted that these projections for China may overstate the growth in China's coal demand as they do not take account of recent changes in the domestic coal market. Insufficient recent data are available to make an accurate assessment of the reported declines in coal production or the likely trends in energy consumption. However, it is unlikely that China's dominance of world energy demand growth would be challenged by these developments. Because of its large size the United States also heavily influences the world energy outlook, accounting for 16 per cent of increased world energy consumption. This is despite moderate GDP growth relative to the developing economies.

Energy consumption in the electricity sector

As referred to above, a key driver of increased energy consumption over the reference case period is the expansion of electricity generation. This is particularly the case in the developing economies where economic growth is high and where continued electrification is expected to accompany economic development (figure 5). In China, for example, electricity output is projected to grow at an annual average rate of 6.3 per cent over the reference case period and at 4.3 per cent in the other Asian economies.

Figure 5: **Absolute increase in fossil fuel consumption, 1995–2010, selected regions, reference case** Million tonnes of oil equivalent



Gas use in electricity generation is projected to increase more strongly than other fossil fuels, reflecting its favored position for power generation across the world (table 1). In most of the developed economies, technological improvements in combined cycle gas turbines, increasing deregulation in electricity markets and the requirement to fit costly pollution control equipment to coal fired plants has generally resulted in gas being the preferred fossil fuel technology for new electricity generation (International Energy Agency 1996). Gas also increases its share of electricity generation in many of the developing economies. However, coal fired electricity generation increases more strongly in economies such as China and Indonesia where large indigenous coal reserves give coal a cost advantage over other technologies.

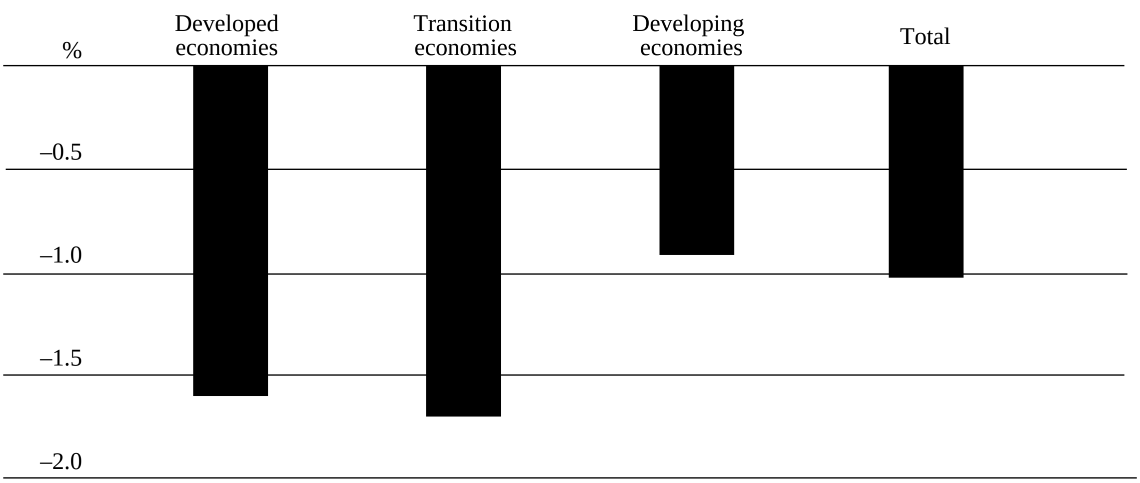
Oil consumption in the power generation sector increases less than consumption of coal and gas because of the relatively high marginal cost of oil fired power generation and ongoing energy security considerations in many economies.

The shares of nuclear, hydropower and other renewable energy sources in total electricity generation decline over the projection period, mainly reflecting continued problems with siting of nuclear and hydro projects and the relatively high cost of nonfossil fuelled power generation.

Table 1: **Share of electricity generated by each fuel , reference case**

	Coal	Oil	Gas	Nuclear	Hydro	Renewables
	%	%	%	%	%	%
1995	36.8	10.5	15.4	18.3	17.9	1.1
2010	36.7	6.8	25.1	13.1	17.3	0.9

Figure 6: **Average annual change in energy intensity, 1995–2010, reference case**



Energy intensity, efficiency and structural change

An important determinant of energy consumption projections is the change in energy intensity over the reference case period. World energy intensity is projected to decline over the reference case by an average of 1 per cent a year. The projected changes in intensity over time vary substantially from region to region (figure 6) and are related primarily to improvements in energy efficiency and changes in economic structure.

Energy efficiency in developing countries is projected to increase more rapidly than in other regions (figure 7). This is because current levels of energy efficiency in developing countries are generally lower than in industrialised countries and there is significant potential for technological catch up. In addition, higher rates of economic growth in developing countries will permit a larger proportion of new, more energy efficient technologies in production and end use capacity.

Figure 7: **Average annual change in energy efficiency, 1995–2010, reference case**

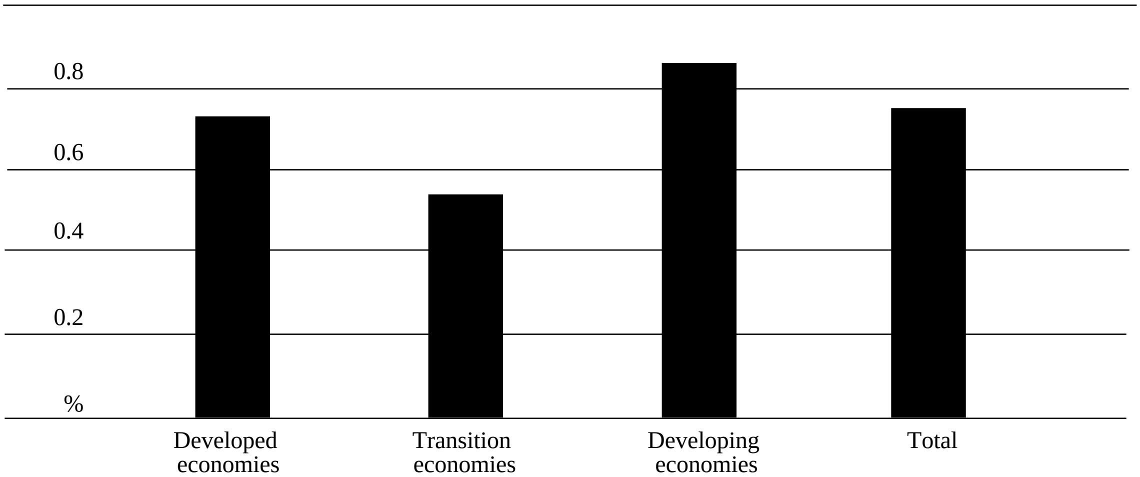
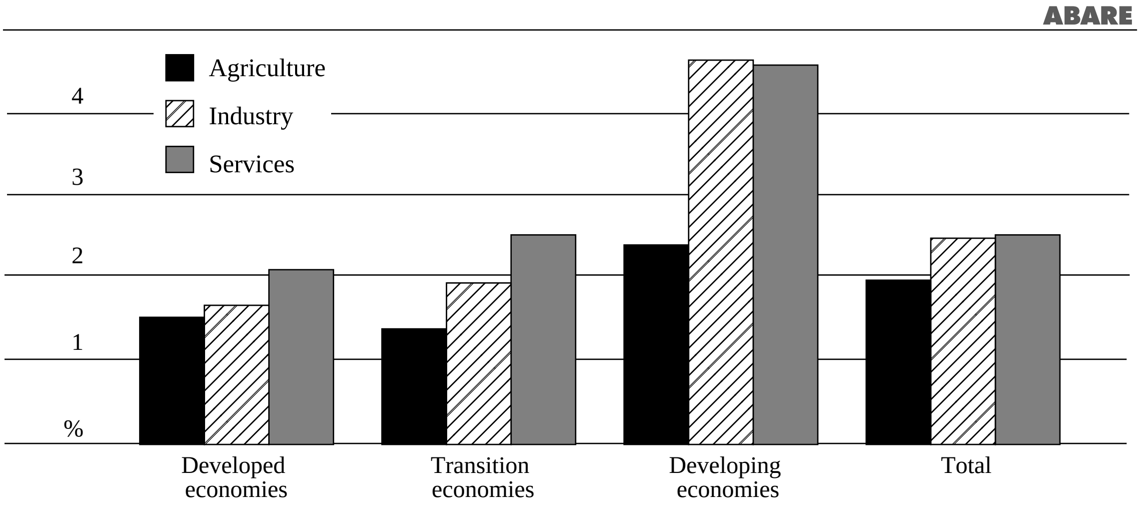


Figure 8: **Average annual change in sectoral output, 1995–2010, reference case**



However, structural change in the developing economies is expected to continue to favor energy intensive industrial sectors (figure 8). This compares with the developed and transition economies where the less energy intensive services sectors, such as the business and financial sectors, are projected to account for the largest share of economic growth. As a result, energy intensity falls less over the reference case in the developing economies than in other regions.

Key uncertainties in the long term outlook for world energy consumption

There are a number of policy issues that could affect the outlook for energy consumption presented above. Climate change response policies, the opening of international trade and investment regimes and the widespread deregulation of electricity markets will be important for energy sector outcomes. Other issues not examined in this paper, including the emerging information economy, could also have significant impacts on energy projections.

To assess the impacts on the energy sector of different policy scenarios a number of policy simulations are examined using GTEM. The estimated impacts of policy changes, such as emission abatement policies or tariff and subsidy reduction measures, on energy variables are defined as the percentage deviations between the equilibrium levels of those variables in the reference case and their equilibrium levels in the policy simulation.

For example, the impact of greenhouse gas emission abatement policies on the level of energy consumption in an economy can be identified by comparing the growth in energy consumption in the policy simulation against energy consumption growth in the reference case, as illustrated in figure 9. To provide a numerical example, consider that reference case energy consumption at 2010 is projected to be 100 million tonnes of oil equivalent (distance *ab*). Following the introduction of emission abatement policies, energy consump-

Figure 9: **Deviation from the reference case in a GTEM simulation**

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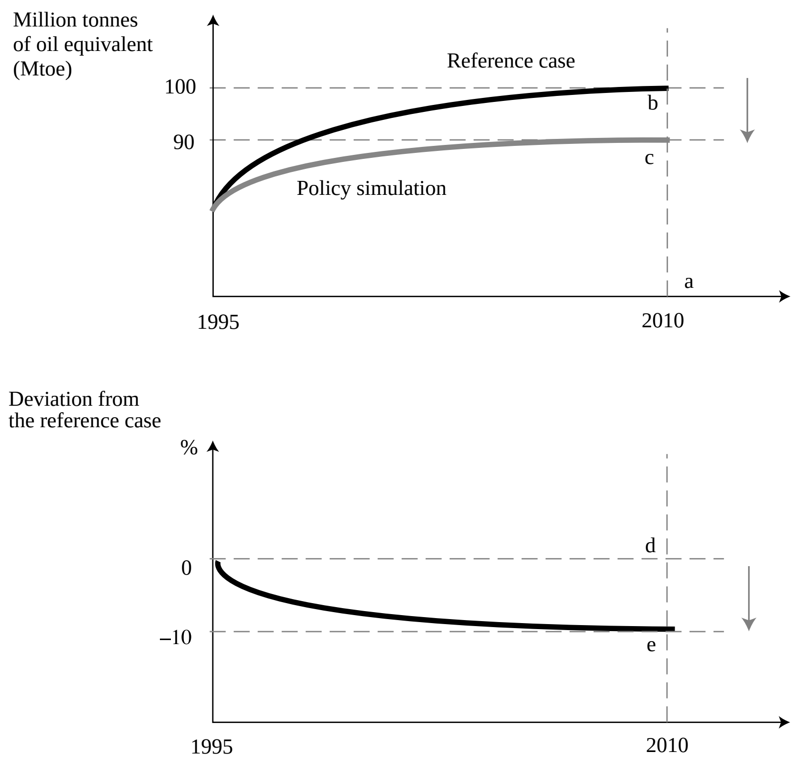


tion at 2010 is projected to be 90 million tonnes of oil equivalent (distance *ac*). This corresponds to the 10 per cent decrease in energy consumption from the reference case (distance *de*). Hence the effect of emission abatement policies in this example would be to decrease energy consumption by 10 per cent compared with the reference case projection for 2010.

Climate change response policies

Widespread concerns about the potential impacts of global climate change and a realisation that effective solutions will require international cooperation have led governments to take a multilateral approach to addressing this issue. This approach has been formalised through the establishment of the United Nations Framework Convention on Climate Change. One of the most significant steps that the parties to the convention have taken to date is the adoption of the Kyoto Protocol. The protocol contains quantified legally binding greenhouse gas emission reduction targets for developed and transition economies, as listed in Annex B of the protocol. It offers the possibility for Annex B parties to use various flexible mechanisms — emissions trading between Annex B economies, the clean development mechanism and joint implementation — to meet their emission reduction commitments in a least cost manner if the protocol enters into force. This will occur when it has been ratified by at least 55 parties to the Convention and by Annex B economies representing 55 per cent of total carbon dioxide equivalent emissions in 1990 from Annex B economies. For a more complete discussion of the provisions of the Kyoto Protocol see Polidano et al. (2000).

In modeling emission abatement in GTEM it is assumed that governments choose policies that impose the least cost on their economies. In GTEM least cost modeling of emission abatement involves imposing a penalty on carbon dioxide equivalent emissions in each period for which emission restrictions apply. The penalty represents the broad class of least cost economic instruments that could be used by governments to reduce emissions. For example, this includes domestic emissions trading and carbon taxes. The penalty raises the costs associated with emission intensive activities in Annex B economies and encourages a shift of resources into less emission intensive activities, thereby reducing emissions. As the most emission intensive activity, combustion of coal attracts the highest penalty.

Emission abatement also has significant trade impacts as it affects the relative prices of fossil fuels and fossil fuel intensive outputs between Annex B and non-Annex B economies. For example, abatement policies will tend to reduce the global demand for fossil fuels, thereby exerting downward pressure on global fossil fuel prices. Together, these effects have the potential to cause profound changes in the level and pattern of world energy consumption, production and trade.

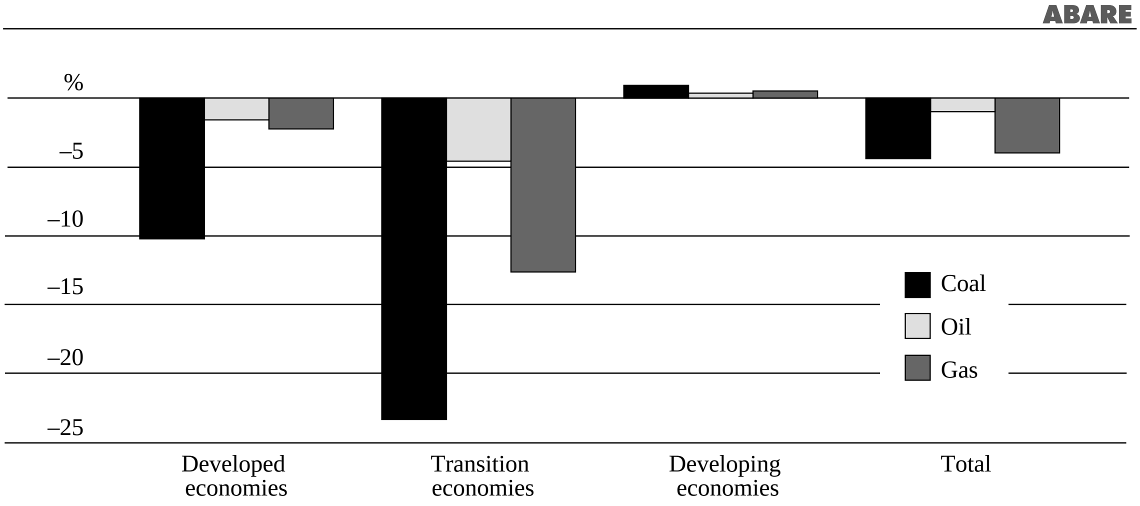
The impacts of responses to climate change

In the policy simulation presented in this paper, Annex B countries are assumed to progressively reduce national emissions of greenhouse gases until they reach their Kyoto target in the year 2010 (under the terms of the Kyoto Protocol, countries are required to meet their emissions targets over an average of the years 2008–12). The emission abatement target for each Annex B country has been adjusted to account for the effects of carbon sequestration in Annex B countries. These adjustments are based on preliminary estimates of carbon sequestration by forestry activities in Annex B regions as permitted under Article 3.3 of the protocol. For a more detailed description of modeling the Kyoto Protocol commitments with GTEM see Polidano et al. (2000).

The impacts on world energy consumption as a result of meeting the Kyoto commitments are examined assuming that an international system of tradable emission quotas is implemented. This allows a least cost response to climate change because countries are able to take advantage of lower cost emission abatement opportunities in other countries. Under an independent emission abatement scenario, where each country meets its target through domestic policies only, energy consumption impacts are significantly larger (Polidano et al. 2000).

The simulation results indicate that action to reduce greenhouse gas emissions in Annex B countries could have significant impacts on energy consumption. Globally, consumption of

Figure 10: **Change in fossil fuel consumption, 2010, relative to the reference case**



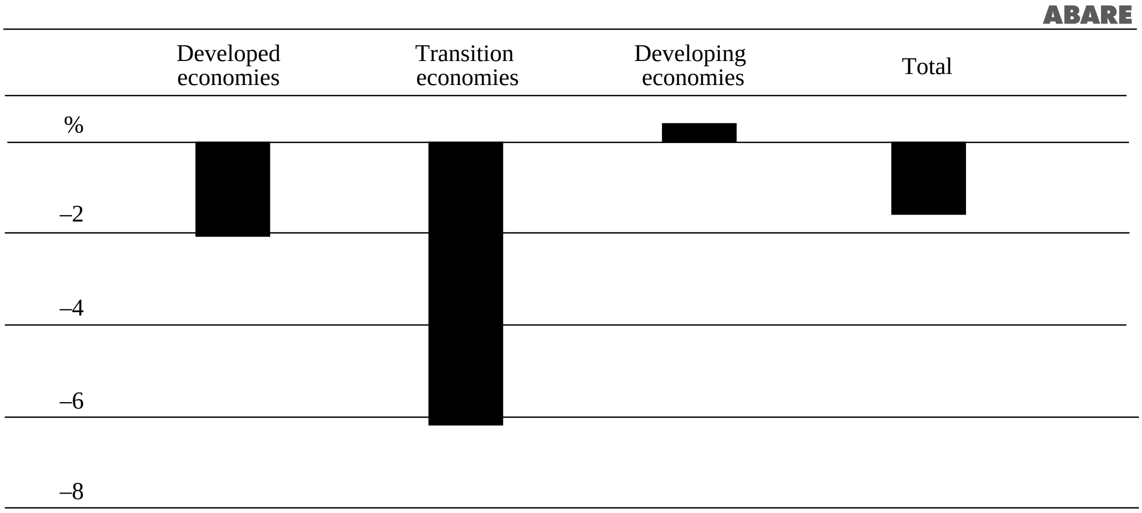
coal, oil and gas decline relative to the reference case by 2010 (figure 10). Different fossil fuels are projected to be affected to varying degrees. Consumption of coal is projected to fall the most as it attracts the highest carbon equivalent penalty. The use of natural gas, the least emission intensive fossil fuel, is projected to be less affected than coal because the carbon equivalent penalty per energy unit is lower. Some substitution away from coal and into gas is projected. World oil demand is projected to be relatively stable because it is mostly consumed in the transport sector where there are limited fuel substitution possibilities.

Changes in fossil fuel consumption arise from changes in levels of electricity generation, the fuel mix and the output of energy intensive commodities — principally iron and steel, nonferrous metals, nonmetallic minerals and chemicals, rubber and plastics. Output in these sectors falls relative to reference case levels in virtually all Annex B economies as the cost of using fossil fuels rises under an emission abatement scenario. As a result, fossil fuel consumption declines in Annex B countries.

The costs of abatement in transition economies are lower than in developed countries, given that production processes in these countries rely heavily on fossil fuel inputs and outdated and ageing technology. As a result, under an international emissions trading scheme these regions reduce emission and energy consumption more than developed countries and sell emission quotas to high abatement cost regions such as Japan.

In non-Annex B countries, where no emission abatement targets apply, considerable improvements in the cost competitiveness of energy intensive industries occur. As a result, the demand for energy in non-Annex B economies increases relative to the reference case (figure 10), leading to carbon equivalent leakage — a rise in non-Annex B emissions as a result of emission abatement in Annex B economies.

Figure 11: **Change in total electricity generation, 2010, relative to the reference case**



Emission abatement has a large impact on the level of power generation in Annex B countries, especially coal fired. As the cost of using fossil fuels increases and overall economic activity contracts, the demand for electricity declines (figure 11). Further, as the cost of using coal in the electricity sector of Annex B countries increases relative to other fossil fuels because of its relative emissions intensity, Annex B countries substitute away from coal toward less emissions intensive fuels, especially gas and renewables (table 2). The extent of this substitution depends on the importance of coal in the reference case fuel mix and on the relative cost of other potential fuels, such as renewables. In developing countries the increase in production of energy intensive goods resulting from carbon equivalent leakage leads to a rise in electricity generation, relative to the reference case.

Trade liberalisation

Liberalisation of the world trade system is being pursued under a range of multilateral (WTO), regional (APEC, NAFTA, ASEAN) and bilateral agendas (Australia–New Zealand Closer Economic Relations), as well as unilaterally. The APEC agenda differs from most other regional and bilateral trade agreements as liberalisation is pursued on the basis of ‘open regionalism’ such that there is no discrimination against non-participants. As a result, trade liberalisation under such an agreement is likely to deliver greater benefits to individual countries and the world economy. This is because openness increases the scope for

Table 2: **Share of electricity generated by each fuel at 2010, Annex B economies**

	Coal	Oil	Gas	Nuclear	Hydro	Renewables
	%	%	%	%	%	%
Reference case	34.1	4.2	26.6	18.4	15.4	1.3
Emissions trading	29.4	4.1	27.6	20	17.1	1.9

competition and specialisation in economic activity and, hence, the efficiency gains that are likely to follow from liberalisation.

Trade liberalisation is based on the expectation that open trading regimes will lead to higher national incomes, principally through the impacts of specialisation in economic activity. Reducing tariff and nontariff barriers to trade, as well as lowering other trade distortions such as domestic subsidy and other assistance arrangements, allows an economy to channel its natural, human and technical resources into activities in which they are used more productively. Although there may be costs for some sectors, the more efficient allocation of an economy's resources that is expected to result from trade liberalisation can lead to lower costs of production and higher real output growth for an economy as a whole.

The effects of trade liberalisation are potentially significant for the energy sector because international trade is a key driver of economic growth. Increased economic growth can be expected to generate increased energy consumption and, ultimately, energy production. Because trade liberalisation leads to the movement of resources between sectors in an economy it will also generate different patterns of economic output and energy consumption across economies. This could have important implications for the magnitude and direction of energy trade.

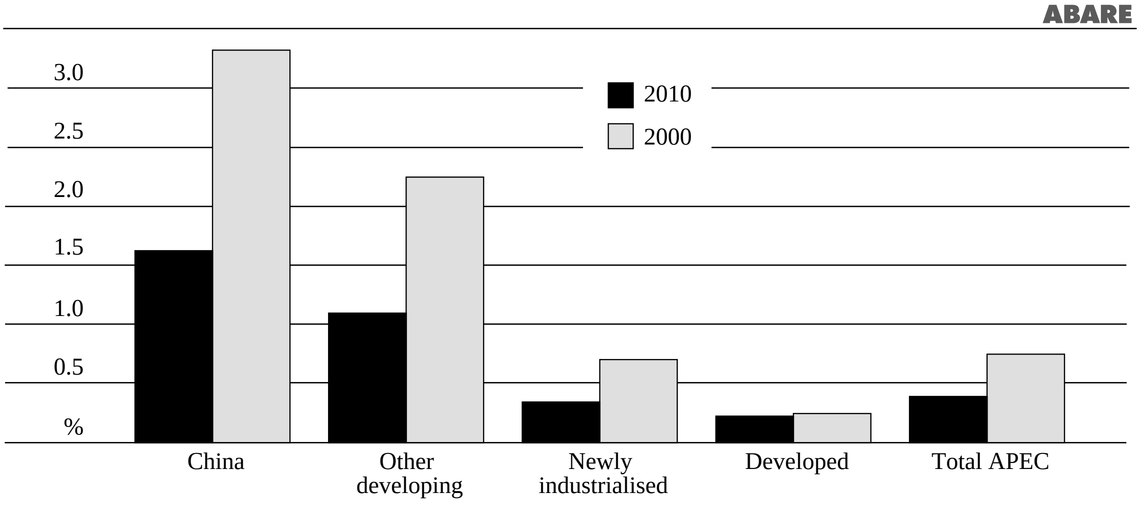
The impacts of trade liberalisation

While trade liberalisation is being pursued under a number of international agendas, the results presented in this paper draw on work undertaken by ABARE for the APEC Energy Working Group on the impacts of the APEC trade liberalisation process (Schneider et al. 2000). This provides a good indication of the effects of broadly based trade liberalisation because APEC includes large economies, such as the United States and Japan, as well as highly protected and rapidly developing economies in east Asia. In addition, because the APEC liberalisation program is nondiscriminatory it is likely to have impacts beyond the immediate region.

Under the APEC agenda, developed and developing economies are assumed to achieve a free and open trade regime by 2010 and 2020 respectively. In the GTEM simulation presented here, all tariff equivalents of tariff and nontariff barriers are assumed to fall to zero for all trade flows into each APEC economy, and all export subsidies and domestic production subsidies in APEC economies are phased out.

The energy sector impacts of trade liberalisation result from a combination of the economic output effects described above and intersectoral effects. The economic output effects are significant. By 2020, the developing economies in APEC could experience increases in GDP of up to 5 per cent relative to the reference case following the implementation of trade liberalisation (figure 12). Newly industrialised and developed APEC economies will, on average, experience smaller increases (0.73 per cent and 0.24 per cent) relative to the

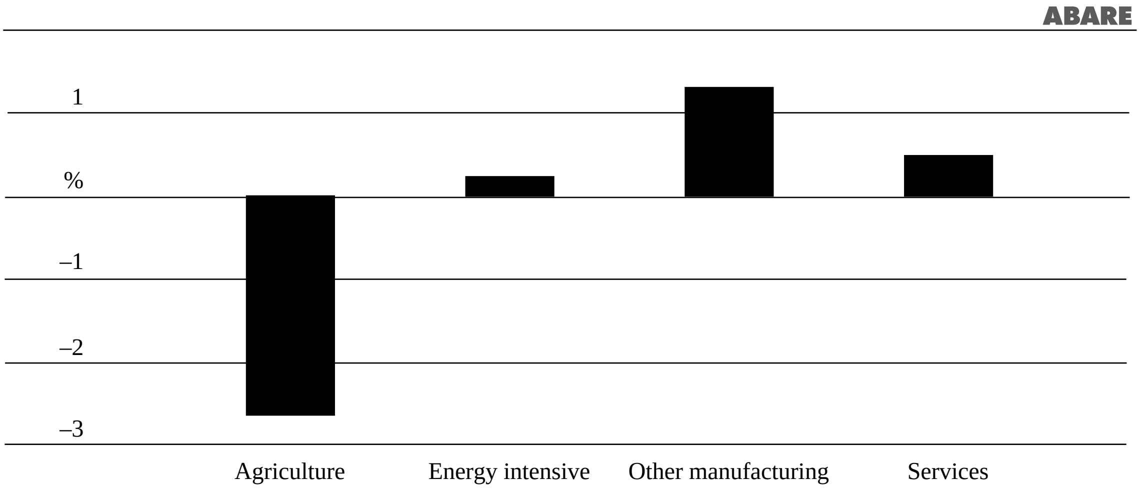
Figure 12: **Change in APEC GDP, relative to the reference case**



reference case because, with some exceptions, they have relatively lower levels of protection. The net effect at the APEC wide level is an increase in GDP of 0.75 per cent relative to the reference case. This is equivalent to additional economic output in the region at 2020 of approximately US$225 billion (at 1995 prices) — larger than the current Indonesian economy and approaching the size of the current economy of Chinese Taipei.

Intersectoral effects are also important. In the developing economies in particular, a major impact of liberalisation is to reduce the assistance (often substantial) that is provided to domestic agricultural industries. As a result, resources (capital and labor) previously consumed in the agriculture sector will shift to sectors in which these economies have a stronger comparative advantage. These include more energy intensive sectors such as heavy industry and manufacturing which, together with the services sector, account for increased electricity consumption in developing economies.

Figure 13: **Change in APEC production in selected sectors, 2020, relative to the reference case**



In the developed economies, agricultural output declines relative to the reference case as the high levels of assistance in some economies are removed. Resources shift into energy intensive industries to a limited degree. The small declines in output of electricity, petroleum and coal products and other manufacturing result in some reduction in coal, oil and gas consumption relative to the reference case. On balance, APEC agricultural production decreases while output in the energy intensive, other manufacturing and services sectors increases relative to the reference case (figure 13).

Energy consumption impacts

The interaction of the macroeconomic and sectoral impacts of APEC trade liberalisation leads to some quite substantial changes in energy consumption in APEC relative to the reference case. As shown in figure 14, there are varying impacts on the consumption of different fossil fuels in different economies. Oil consumption rises relative to the reference case in the newly industrialised economies. This is mainly because demand for transport services (including international transport for trade), which accounts for the largest share of oil consumption, increases as a result of increased per person incomes and increased trade flows among economies. Oil consumption declines relative to the reference case in China because of reduced consumption in energy intensive industry, particularly China's large chemicals, rubber and plastics sector. Demand for coal in industry and power generation in the developing and newly industrialised economies increases relative to the reference case, while reduced demand in these sectors leads to a fall in coal consumption in the developed economies. Gas consumption increases relative to the reference case in economies where energy intensive production and electricity generation increase as a result of liberalisation. This includes a number of developing and newly industrialised economies. This is partly offset by falls in gas consumption relative to the reference case in Indonesia and Mexico, both of which are relatively large consumers of gas in the regional context. Gas consumption in Indonesia and Mexico falls as a result of the removal of large

Figure 14: **Change in coal, oil and gas consumption, 2020, relative to the reference case**

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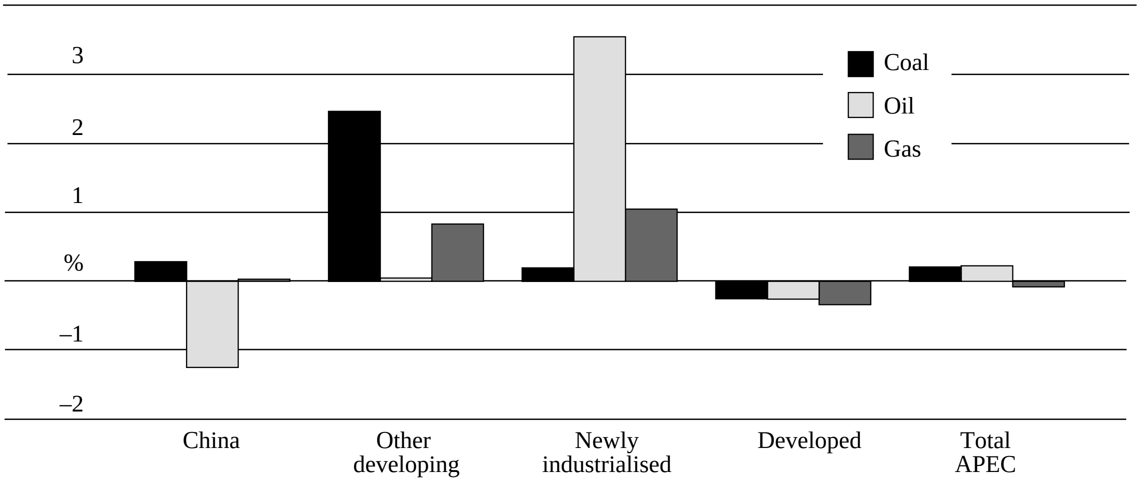
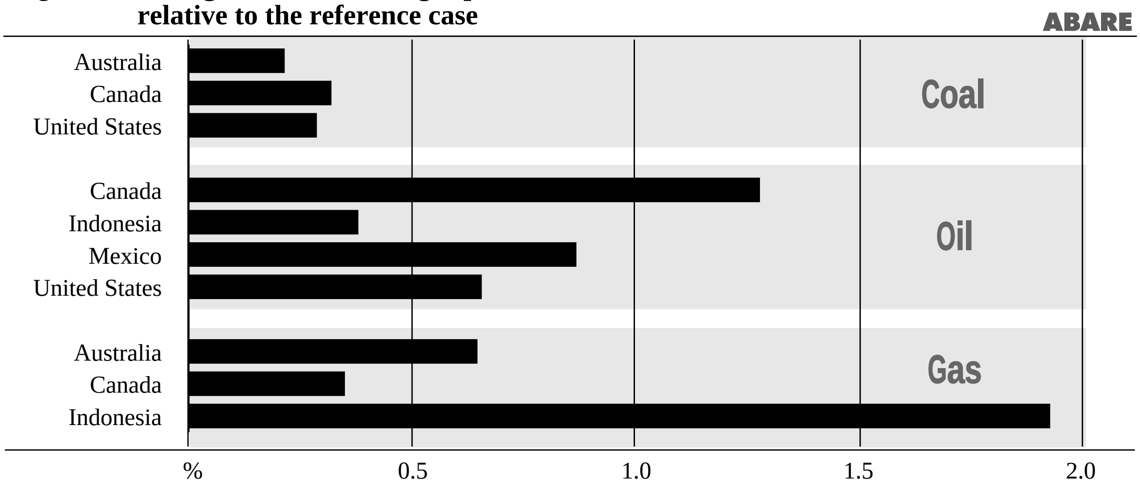


production subsidies in gas intensive industries in these economies. These are insufficient to outweigh the increases in other developing and newly industrialised economies, however, and total gas consumption in these regions in 2020 is higher than in the reference case.

Energy production impacts

Trade liberalisation in APEC results in increased regional production of fossil fuels in 2020 relative to the reference case, despite there being no large increase in the total level of APEC energy consumption (figure 15). As a result of trade liberalisation, resource shifts make APEC exports of energy more competitive on international markets and APEC becomes a more important supplier of coal and gas to the rest of the world. A significant driver of the changes in energy production are the resource shifts that arise from liberalisation in the major energy producing economies. For example, production of coal, oil and gas in 2020 is higher than in the reference case in Australia, Canada and the United States.

Figure 15: **Change in coal, oil and gas production in selected APEC economies, 2020, relative to the reference case**

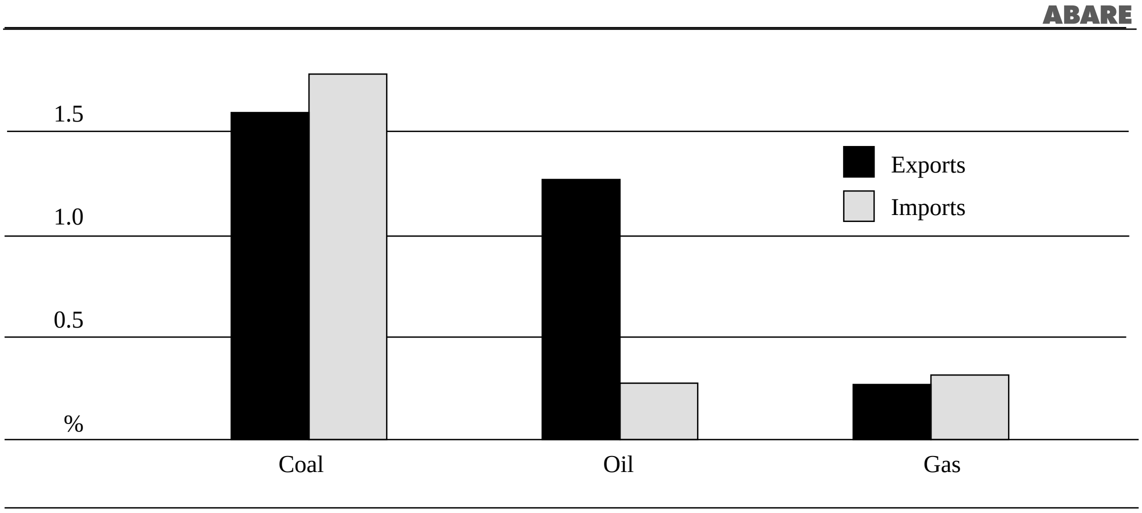


In these economies, trade liberalisation results in the release of resources from previously protected industries, such as agriculture and manufacturing, and increasing specialisation in resource based sectors, including energy. In contrast, coal production in China remains unchanged compared with reference case levels despite increased coal consumption. This is because resources are reallocated toward other sectors such as textiles and other manufacturing where comparative advantage increases most as a result of APEC-wide trade liberalisation.

Trade impacts

Fossil fuel trade in the APEC region in 2020 increases significantly relative to the reference case as a result of liberalisation, due mainly to the balance of the consumption and produc-

Figure 16: **Change in APEC coal, oil and gas trade, 2020, relative to the reference case**



tion impacts (figure 16). The removal of barriers on fossil fuel imports also has a positive impact on the level of APEC fuel trade.

The largest changes are in coal trade, mainly reflecting strong growth in coal fired power generation throughout the region. The majority of the increased demand for imported fossil fuels in APEC occurs in the region's key import markets — Japan, Korea and Chinese Taipei — as their economies grow and as energy intensive output increases as a result of liberalisation. The same forces underpin increased imports of energy relative to the reference case in a number of developing APEC economies.

While trade impacts arise mainly from the balance of the consumption and production impacts of liberalisation, the removal of barriers on fossil fuel imports also has an impact on the level of APEC fuel trade. For example, the removal of tariffs on imported coal in Chile, Malaysia and the Philippines encourages coal imports. Similarly, the removal of tariffs on oil imports in Korea and Chinese Taipei, as well as in smaller import markets such as Chile, promotes increased oil imports relative to the reference case.

APEC's major coal exporters — Australia, Canada and the United States — meet most of the increase in demand for coal imports relative to the reference case. Oil exports increase from Mexico, Canada and Indonesia. Malaysia's oil exports are constrained by strong increases in domestic energy consumption as a result of the economic gains that flow from liberalisation. This also reduces Malaysia's gas exports relative to the reference case, allowing Australia and Indonesia to significantly increase exports of gas. The absolute level of Malaysia's gas exports does not fall, however, and Malaysia is well able to maintain its long term contractual commitments.

Energy sector deregulation

The deregulation of electricity supply industries has become an important focus of energy policy in many economies. The reform agenda is being driven by the imperative to deliver electricity services in the most efficient manner possible and at the lowest prices, while ensuring sufficient financial capacity to invest in system expansion. It is evident from experience in some economies, including the United Kingdom and Australia, that deregulation of the electricity sector can have significant consequences for electricity prices, demand and fuel choice. To illustrate these potential changes a brief case study has been undertaken of the impacts on the energy sector in one economy where electricity markets are highly regulated and where this is likely to be a constraint on productivity and growth. Japan has been chosen as the subject of the case study because its electricity sector meets both of the above criteria.

The Japanese electricity industry is subject to regulation in two key areas — fuel procurement and the existence of regional electricity supply monopolies. Under current policy parameters, the electricity utilities have an informal agreement to purchase all of Japan's domestic coal production, the level of which is determined by the government. Under the government agenda of reducing domestic coal industry support, domestic coal prices have declined since 1990 but are still significantly above international coal prices. In 1997, for example, domestic steaming coal prices exceeded import prices by more than three and a half times (table 3). This adds significantly to total electricity industry costs, which are passed on to consumers in the form of higher electricity prices. By limiting competition in electricity supply, the regional monopoly framework also contributes to higher end use prices. As a result partly of these regulations, electricity prices in Japan are the highest in the OECD (figure 17).

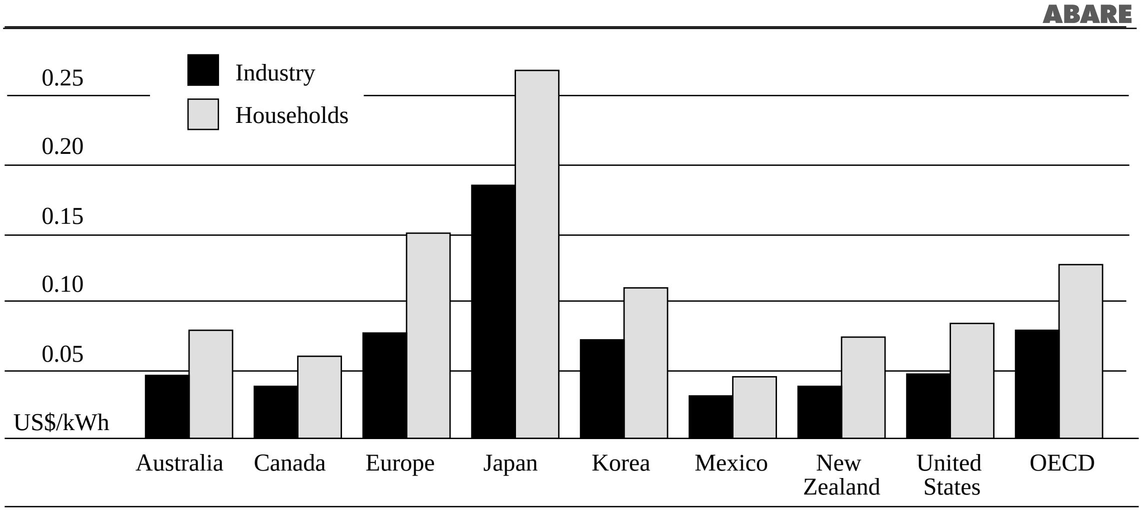
Recognising the importance of the electricity sector for economic growth and efficiency, the Japanese government has commenced a program of reforms that addresses both the fuel procurement and the regional monopoly issues. Prices for domestic coal used in the

Table 3: **Domestic and imported steam coal in power generation in Japan**

	Domestic		Imported		Average
	Mt	¥/t	Mt	¥/t	¥/t
1990	8.9	20 966	17.4	7 347	11 956
1991	8.2	20 966	21.2	6 781	10 737
1992	7.7	19 936	23.8	6 135	9 509
1993	7.3	19 936	26.3	5 081	8 308
1994	6.7	19 936	31.6	4 472	7 177
1995	6.2	19 936	35.2	4 509	6 819
1996	6.1	19 936	35.8	5 334	7 460
1997	4.8	19 273	41.7	5 448	6 875

Source: IEA (2000).

Figure 17: **OECD electricity prices, 1995**



Source: IEA (2000).

electricity industry are being reduced progressively and the amount of coal purchased by the utilities is also declining. Partial competition has also been introduced into the electricity supply industry since 1995 with the provision for independent power producers to enter the wholesale market. The reform process is expected to continue with the introduction of competitive bidding for all new thermal power stations coming on stream from 2008 and deregulation of power sales to large customers from 2000.

Both aspects of deregulation — the elimination of the domestic coal purchase requirement and the introduction of competition in electricity supply — have been modeled using GTEM. Modeling the removal of the domestic coal purchase requirement involves reducing the average price paid for coal by the electricity utilities to international levels over the period from 2000 to 2010. Increasing competition in the electricity supply industry is modeled by introducing productivity improvements in the industry that are sufficient to reduce electricity prices by 30 per cent. This is based on information in the first tenders for independent power producers since partial deregulation in which successful bids involved prices that averaged 30 per cent below current costs of production. Assuming that independent power producers have available the same range of inputs (capital, labor, fuels and other intermediate inputs) at the same prices as the existing utilities, the price difference implies that the independent producers expect to be able to generate electricity significantly more efficiently than the utilities. That is, the difference of 30 per cent between the current price of electricity and the average bid price is an indication of the possible productivity gains available to the electricity industry in Japan in a more competitive, deregulated environment. These cost savings will only be possible if a regulatory system is put in place that ensures non-discriminatory access conditions and economically rational pricing for services required by independent power producers that will not be subject to competition, such as transmission services (OECD 1999).

Energy sector deregulation impacts

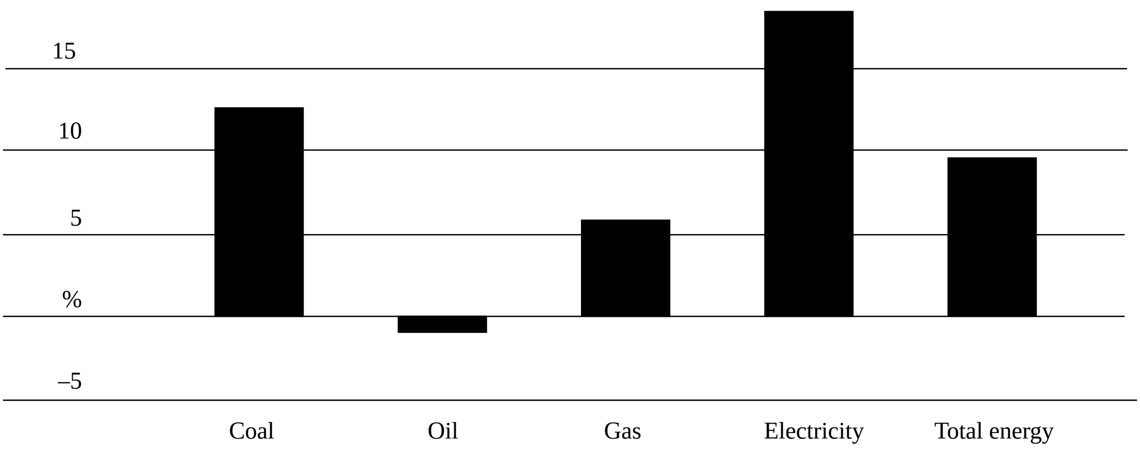
At the macro level, the results indicate that following deregulation, Japan's GDP at 2010 could be 1.3 per cent or US$84 billion higher (at 1995 prices) than the reference case. The magnitude of the gains from deregulation are not surprising given that electricity production in Japan accounts for approximately 4 per cent of GDP and that the reform process as modeled results in the cost of electricity production falling by thirty percent relative to the reference case. Given that electricity is used throughout the economy, the large productivity gains that are derived from deregulation are captured by all sectors.

Also important are the changes that occur in total electricity consumption following deregulation and in the level of fuel consumption in the electricity sector. Because productivity improvements in electricity production reduce the price of electricity, demand for electricity rises in both industrial use and private consumption (figure 18). The elimination of the coal procurement policy also means that the relative price of coal in electricity generation falls and coal becomes the preferred fuel for the increased electricity output. As a result, coal use in the electricity sector at 2010 is 12.1 per cent higher than in the reference case. This is equivalent to an increase in steaming coal imports of approximately 19 million tonnes. Gas use in power generation also increases relative to the reference case, although this is constrained by the lower coal prices. Higher GDP growth that results from the fall in electricity prices also leads to increased total energy use throughout the economy (figure 18).

It should be noted that the impacts of deregulation outlined above are assumed to occur in isolation from other policies related to the energy sector, including climate change response policies. If Japan were to adopt the deregulation policies outlined here at the same time as participating in an emissions trading scheme it would be required to purchase more greenhouse gas permits to ensure that it could meet it's commitments under the Kyoto Protocol.

Figure 18 : **Change in Japanese energy consumption, 2010, relative to the reference case**

ABARE



Given that Japan's electricity sector is highly regulated, the magnitude of the economic gains from deregulation and the changes in energy consumption reported above may not be reflected elsewhere. The structure of the electricity sector varies considerably across economies and many economies have made considerable progress in deregulating their electricity supply industries. Nevertheless, the results illustrate that the impacts of further electricity sector deregulation could have important implications for the energy sector as well as making a significant contribution to economic growth and efficiency.

Conclusions

Energy will continue to play a key role in underpinning economic growth and development over the next decade. Despite structural changes in some economies that favor less energy intensive output and ongoing energy efficiency improvements, energy demand can be expected to rise strongly over this period. However, there is a range of possible government policies that could have a significant impact on this outlook. International climate change response policies, for example, are likely to significantly reduce the overall level of energy consumption in developed and transition economies while leading to higher energy consumption in developing economies through the impacts of emissions leakage. Trade liberalisation policies could also have important impacts on fossil fuel markets. For example, the shifts in energy production and consumption that are likely to follow liberalisation could have significant implications for the pattern of world energy trade. Widespread initiatives to deregulate the electricity sector in many economies could also alter the level of electricity output and the power generation fuel mix. Where deregulation leads to lower domestic energy prices total energy use is likely to rise. This increase in energy consumption is likely to be satisfied by the most competitively priced fuels.

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