energy security, clean technology development and climate change

addressing the future challenges in APEC

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foreword

The importance of energy security and sustainable economic development in APEC economies continues to heighten in response to rapid growth in energy consumption, increasing dependence on energy imports and growing concerns about the potential economic impacts of climate change.

Cleaner and more advanced energy efficient and lower emission technologies are an essential component of any approach that aims to ease the pressure of growing energy demand and to reduce growth in greenhouse gas emissions, while allowing APEC economies to pursue a range of other policy objectives, including improving energy security and economic growth and development.

In this report the potential energy consumption and greenhouse gas emission impacts of a concerted effort within APEC economies to develop and widely deploy current and advanced energy efficient and low emission technologies and energy sources across all sectors of the economy are assessed. Decreasing emissions from the forestry sector and increasing carbon sequestration in forestry through activities such as lowering the rate of deforestation, increasing the establishment of forests and improving forest management are also projected to play an important role in reducing growth in greenhouse gas emissions.

The results indicate that the development and widespread uptake of energy efficient and advanced low emission technologies can significantly reduce the growth of energy consumption and greenhouse gas emissions. This is expected to improve energy security in the APEC region. In order to achieve these outcomes, collaborative efforts to remove the barriers to technology development and uptake and reduce forestry emissions are required throughout APEC.

Phillip Glyde
Executive Director
September 2007

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abbreviations and acronyms

AP6	Asia Pacific Partnership on Clean Development and Climate Change
APEC	Asia Pacific Economic Cooperation
CCS	carbon capture and storage
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
FAO	Food and Agricultural Organisation of the United Nations
GDP	gross domestic product
Gt	gigatonnes (billion tonnes)
Gtoe	gigatonnes of oil equivalent
IEA	International Energy Agency
IGCC	integrated gasification combined cycle
IPR	intellectual property rights
Mt	million tonnes
NGCC	natural gas combined cycle
OECD	Organisation for Economic Cooperation and Development
R&D	research and development
TWh	terawatt hours

summary

» The weight of global economic activity has shifted to the APEC region in recent years, driven particularly by strong growth in major developing economies in the region.

- In 2004 APEC economies accounted for around 61 per cent of global economic output.

» Access to affordable and reliable energy supplies and open markets for trade and investment will allow the APEC economic success story to continue.

- While the rate of economic growth is projected to moderate over the projection period, 2004–50, it is expected that the APEC region will still grow on average at about 3.0 per cent a year.

» Continued economic growth will provide APEC economies with the means to achieve many of their economic and social development goals over the period to 2050.

» Continued economic expansion is expected to lead to strong growth in energy consumption. Greenhouse gas emissions in the region are also projected to increase.

- In 2004 APEC economies accounted for about 60 per cent of global energy consumption.
- Under current policy settings, energy consumption in APEC economies is projected to increase by about 139 per cent from 5.8 gigatonnes of oil equivalent (Gtoe) in 2004 to 13.7 Gtoe in 2050.

» Fossil fuels currently provide the bulk of energy demanded by APEC economies and are projected to continue to do so over the period to 2050.

- Under a continuation of current policy settings, sources of energy supply for the APEC region in 2050 are estimated to be: coal 29 per cent, oil 31 per cent, gas 25 per cent, nuclear 9 per cent, hydroelectricity 2 per cent and biomass and other renewables 4 per cent.

» In 2004 APEC economies accounted for about 58 per cent of global greenhouse gas emissions. Under current policy settings, a continued reliance on fossil fuels to meet escalating energy demand is projected to lead to a marked increase in greenhouse gas emissions.

  - By 2050, under current policy settings, greenhouse gas emissions are projected to be about 130 per cent higher in APEC economies relative to 2004 levels. At 2050, APEC economies are projected to account for about 54 per cent of global greenhouse gas emissions.

» Rapid growth in energy consumption, increasing dependence on energy imports and growing environmental concerns have made energy security and sustainable development key issues for consideration by APEC economies in recent years.

» APEC economies will need to implement a range of measures to achieve their economic and development goals and limit the increase in greenhouse gas emissions.

» Cleaner and more advanced energy efficient and lower emission technologies are an essential component of any approach that aims to ease the pressure of growing energy demand and to reduce growth in greenhouse gas emissions, while allowing APEC economies to maintain economic growth and development and to pursue a range of other policy objectives including improving energy security.

» The widespread deployment and adoption of cleaner, more advanced and energy efficient technologies (including carbon capture and storage – CCS) has the potential to considerably reduce the overall demand for energy, significantly decarbonise the energy and electricity supply sectors and reduce the growth in greenhouse gas emissions in APEC economies over the medium to long term.

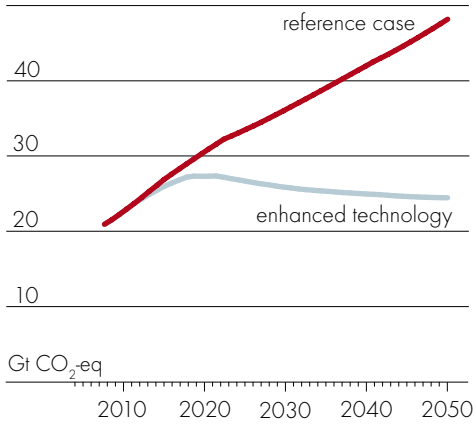
  - The development and uptake of such advanced technologies (which are currently considered plausible) in APEC economies could reduce APEC emissions by about 49 per cent relative to what would otherwise be the case at 2050 (figure 1).

» Although the development and diffusion of advanced technologies can reduce growth in greenhouse gas emissions, emissions in APEC are still projected to be higher than 2004 levels in 2050, even after the enhanced uptake of these technologies.

» Active involvement of the governments of APEC economies and the implementation of a wide range of policies and measures tailored to the individual

circumstances of APEC economies will be required for the enhanced development, adoption, diffusion and transfer of cleaner and more advanced energy efficient technologies.

fig 1 **APEC greenhouse gas emissions**



» Such measures could include collaborative efforts with industry on research and development; the introduction of performance and emissions standards; introducing and enforcing adequate and appropriate intellectual property rights regimes; the provision of relevant education and training initiatives; measures to enhance capacity building and technological assistance between APEC economies; and the use of economic instruments, such as taxes, subsidies and emissions trading. Approaches will vary depending on the circumstances and capacities of different economies.

» However, further reductions in emissions may be possible with development and deployment of low and near zero emissions technologies beyond those analysed in this report. Further research and development in combination with appropriate policy approaches, including pervasive carbon pricing, could bring forward additional low and near zero emission technologies that would further reduce the link between economic growth and emissions.

» In order to achieve further reductions in greenhouse gas emissions in the APEC region, governments may also choose to increase terrestrial sinks in forestry areas by fostering sustainable forest management and lowering the rate of deforestation. APEC economies in particular have a role to play here as they account for around 54 per cent of the global managed and natural forest area.

- If APEC were able to halve current deforestation rates in tropical Asian member economies over the period 2009-50 this would lead to an estimated 70 per cent fall in forestry related emissions in these economies at 2050 compared with what otherwise would be the case.

» Maintaining economic growth, achieving development goals and limiting greenhouse gas emissions in APEC poses significant challenges. Member economies will need to choose instruments, policies and practices that best suit their individual circumstances and that achieve these goals at least cost, maintain open markets for goods and services and promote collaboration on the development and deployment of energy efficient and lower emissions technologies. Cleaner technologies and sustainable forestry policies have the potential to contribute significantly in this context.

1

introduction

APEC (Asia Pacific Economic Cooperation) economies account for over half of the world's energy use, economic output and greenhouse gas emissions and over a third of the world's population. As a result APEC economies have a large influence on global economic, social and environmental outcomes.

economic growth

In 2004, APEC accounted for about 61 per cent of world economic output. Growth in gross domestic product (GDP) in APEC economies is, however, projected to slow over the projection period, 2004–50, reflecting falling labour supply growth and lower productivity growth in most APEC economies. The average annual growth in GDP in APEC between 2004 and 2050 is projected to be about 3.0 per cent, ranging from an average of 1.3 per cent in Japan to 5.3 per cent in China.

energy consumption

Demand for energy in the APEC region is expected to rise significantly over the coming decades, driven by increasing populations and expanding economic activity, particularly in developing economies. In 2004, APEC accounted for 60 per cent of the world's primary energy consumption. Energy consumption in APEC economies is currently dominated by fossil fuels, which are greenhouse gas emission intensive sources of energy. Total primary energy consumption in the APEC region in 2004 was sourced from

APEC member economies

founding members (1989)
Australia
Brunei Darussalam
Canada
Indonesia
Japan
Korea, Republic of
Malaysia
New Zealand
Philippines
Singapore
Thailand
United States

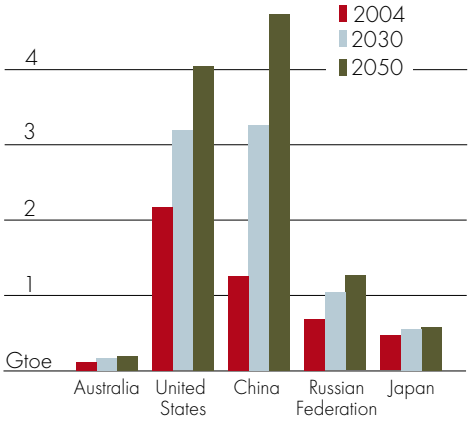
first enlargement (1991)
People's Republic of China
Hong Kong, China
Chinese Taipei

second enlargement (1993)
Mexico
Papua New Guinea

third enlargement (1994)
Chile

fourth enlargement (1998)
Peru
Russian Federation
Viet Nam

fig A **primary energy consumption in selected APEC economies – reference case**



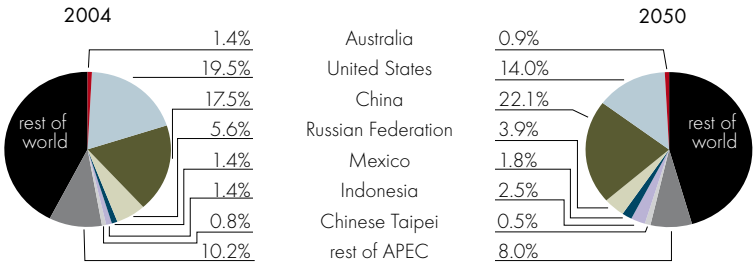
oil (33 per cent), coal (33 per cent) gas (24 per cent), nuclear (7 per cent), hydroelectricity (2 per cent), biomass (0.8 per cent) and other renewables (0.3 per cent).

Demand for energy intensive goods and services are driven by increases in GDP and population. Strong economic performance in APEC developing economies, especially China, is projected to lead to rapid increases in total regional primary energy consumption (figure A). Primary energy consumption in the APEC region is projected to increase by nearly 140 per cent from 5.8 Gtoe in 2004 to 13.7 Gtoe in 2050. Energy consumption is expected to increase by about 225 per cent in the lower income APEC economies and by just 75 per cent in the higher income APEC economies between 2004 and 2050. By 2050, APEC is expected to account for 56 per cent of global primary energy consumption.

greenhouse gas emissions

The projected increases in energy consumption will lead to rising greenhouse gas emissions from the APEC region given the projected continued reliance on fossil fuels to meet growing demand. The future energy fuel mix and energy efficiency of current and future technologies will influence the level of greenhouse gas emissions in the future. Structural shifts from energy intensive industry to service oriented activities over the medium to long term will also alter future emission levels from APEC member economies. Greenhouse gas emissions in APEC are projected to increase by about 130 per cent from around 20.9 Gt CO_2-eq in 2004 to 48.2 Gt CO_2-eq in 2050. In 2004, APEC economies accounted for about 58 per cent of global greenhouse emissions. This is projected to fall to 54 per cent in 2050 (figure B).

fig B **contribution to global emissions – APEC economies and rest of world**



APEC – addressing the climate change challenge

The challenge for APEC economies will be to meet this growing demand for energy services and development needs while simultaneously achieving environmental objectives, including the reduction of global greenhouse gas emissions.

APEC leaders have noted the importance of meeting developmental goals and growing energy demand while minimising adverse impacts on the environment (APEC 2005, 2006). However, diversity in economic, social and other factors (such as economic size, structure and income levels) lead to differing economic and environmental policy objectives. Although most APEC economies have instituted a range of policies designed to address energy security and environmental concerns, the focus on environmental issues, particularly climate change, tends to be greater in higher income economies than in lower income economies. In lower income economies, policies designed to address development and economic growth objectives generally take precedence over policies to mitigate greenhouse gas emissions and other polluting substances.

To implement policies that address human induced climate change without compromising the ability of economies to develop and improve the wellbeing of their citizens, the climate change policy framework should adhere to three fundamental principles – environmental effectiveness, economic efficiency, and equity.

To provide energy services and simultaneously mitigate emissions, targeted investment in research and development (R&D) aimed at developing advanced energy efficient and low emission technologies will be required. This investment would accelerate the development, transfer and uptake of advanced and cleaner

technologies – the key to weakening the link between economic growth and greenhouse gas emissions.

Governments have a key role to play in stimulating R&D in energy efficient and low emission technologies and encouraging the uptake of advanced and cleaner technologies by creating an environment conducive to the development and transfer of these technologies. Governments also need to address market barriers to the uptake of currently commercially available energy efficient and low emission technologies.

In addition to the uptake of advanced technologies there are considerable options for reducing atmospheric greenhouse gases through terrestrial sequestration in forestry. The APEC region accounts for around 54 per cent of the world's forest area (FAO 2007).

To address climate change in the long term, a portfolio of measures is required, including technology standards and R&D, information campaigns, government regulation, financial incentives, and market based mechanisms to establish a price for carbon. Policy measures to foster sustainable forest management and reduce deforestation can also play an important role as part of a broader portfolio of practical measures.

In this report, the potential energy consumption and emissions impacts of the enhanced development and uptake of advanced energy efficient and low emission technologies are considered, with a focus on APEC economies. The potential role of terrestrial sequestration in forestry in APEC economies is also considered.

2

role of cleaner technologies

The key to simultaneously pursuing mitigation and adaptation strategies to address the climate change challenge while achieving other economic and social objectives is through the development and increased uptake of energy efficient, low emission and adaptation technologies and measures. In this chapter, the role of mitigation technologies is considered.

clean technologies

weakening the link between economic growth, energy consumption and greenhouse gas emissions

In the short to medium term, uptake of a broad range of currently available low emission technologies and measures – including more energy efficient production and end use systems – will be required to slow global emissions growth. The widespread and earlier uptake of more efficient energy technologies will also decrease the requirement for new energy infrastructure in the short to medium term. Over the longer term, more advanced technologies that are currently in the developmental stage that significantly reduce the link between economic growth and fossil fuel use and emissions will be required to achieve significant cuts in emissions. These technologies must also address the cost, intermittency, safety, and infrastructural challenges associated with the widespread uptake of energy efficient and low emission technologies and energy sources.

key mitigation technologies

electricity and heat generation

Electricity and heat generation currently accounts for about 34 per cent of APEC's total greenhouse gas emissions. Decarbonising electricity and heat generation will be a key to reducing emissions growth. In the medium to long term a range of low emission electricity and heat generation technologies could potentially be widely deployed. These technologies include more efficient coal and gas fired electricity technologies in combination with carbon capture and storage (CCS),

advanced nuclear generators and various advanced renewable technologies, including high efficiency photovoltaic power, large advanced wind generators, biomass gasification plants, geothermal hot rocks and tidal power. Various supply, infrastructure and cost constraints prevent any one of these technologies from addressing the climate change challenge on its own. For that reason, a portfolio of these technologies will be necessary to lower, both significantly and cost effectively, the emissions intensity of electricity generation.

transport

Transport currently accounts for approximately 20 per cent of APEC's end use sector emissions. In the transport sector considerable abatement potential is available from increasing the efficiency of conventional vehicles and through the widespread uptake of advanced hybrid vehicles and increased use of alternative low emission fuels.

other industries

A range of technologies and management options exist that can reduce future growth in energy consumption and greenhouse gas emissions across all sectors. Energy consumption and greenhouse gas emissions in households, industry, governments and the services sector can be considerably reduced through the widespread uptake of more efficient electric or energy technologies. For example, the use of more efficient lighting technologies, such as compact fluorescent globes or light emitting diodes, can considerably reduce the amount of electricity required to deliver a desired level of lighting. Fugitive emissions in agriculture and industry can also be reduced through technological developments, changes in management practices, capturing fugitive emissions and replacing carbon intensive inputs.

barriers to technology development, uptake and transfer

There are many economic, market, technology and informational barriers that constrain the optimal allocation of resources to developing, deploying and transferring technologies and achieving a rapid acceleration to a low emission intensive global economy.

development

Knowledge generated through R&D is often considered a public good because, in general, spillovers via publication, skills transfer, product demonstrations and reverse engineering mean that others cannot be excluded from using this knowl-

edge and investors are unable to capture all the benefits of their expenditure. As a result, investors do not factor in all the returns (from a societal perspective) when considering the decision to invest in R&D. The level of R&D undertaken will therefore be less than what is socially optimal.

Barriers to the uptake and transfer of energy efficient technologies are another impediment to achieving higher levels of R&D in energy efficient and low emission technologies. Such barriers reduce demand for energy efficient and low emission technologies (relative to the socially optimal level), which reduces the expected returns from investing in R&D of these technologies.

uptake

In the residential, services and light industry sectors, where energy makes up only a relatively small portion of total expenditure, the gap between the optimal and current level of energy efficiency is particularly large as a result of the presence of numerous additional market barriers. These bariers include a lack of information and technical understanding, lack of disposable income for upfront capital investment, split incentives between purchasers of equipment and consumers of energy, inseparability of energy investments from other investments and regulatory policies that discourage investment.

Technology lock-in arises when a competitive advantage results in the mass uptake of a particular technology or fuel on which the economy becomes reliant. Technological lock-in can prevent new technologies from entering the market given the significant costs associated with developing new supporting infrastructure and industries. For example, to switch away from petroleum to hydrogen would require the development of an expensive hydrogen supply system. This is often cited as one of the main barriers to the widespread uptake of hydrogen fuelled vehicles (IEA 2006).

The regulatory environment, which may include taxes and subsidies, can also reduce investment in energy efficiency measures or low emission technologies through their influence on the expected returns from using such technologies. As a result, investments in energy saving technologies are also lower than the socially optimal level. Energy pricing policies in several developing economies, for example, have been identified as an impediment to the development and uptake of renewable energy technologies (APEC 1999).

transfer

A key impediment to the transfer of technologies to developing economies is concern about the protection of intellectual property rights. Investors may be unwilling to fund innovation or product development in an environment of weak intellectual property rights, since other firms cannot be prevented from copying their designs and entering the market and thereby reducing the returns to the original investor. The APEC region could benefit from more uniform and transparent adoption of intellectual property rights so that companies developing technologies in industrialised economies with relatively strong rights are more willing to manufacture and sell their products in developing economies (Crouch 2003).

Macroeconomic conditions can also greatly influence the potential for successful transfer and adoption of energy efficient and low emission technologies in developing economies. High inflation, fluctuating exchange rates, and incomplete pricing of materials, labour, energy and other inputs, as well as trade policies that disallow the free movement of capital all act as impediments to the transfer and adoption of advanced energy efficient and low emission technologies as they significantly increase the risk associated with investment and reduce credit availability.

Inadequate human and institutional capacities may also hamper the diffusion of new technologies. Lack of knowledge, skills and practical experience within the local labour force reduces productivity and impedes the effective implementation, operation and maintenance of technology. Capacity is also an issue in relation to labour having the skills required to undertake technological needs assessments, benefit–cost analyses and environmental impact assessments, which may be necessary in procuring, managing and financing technology (UNEP 2003).

Institutional capacity is also important for providing effective linkages between technology providers, users and developers. Institutional intermediaries are essential in ensuring coordination between various information sources, partnerships and networks to improve technical dissemination. Inadequate infrastructure can also impede investment in low emission energy sources, as projects can be dependent on external infrastructure, such as gas pipelines or electricity grids. If infrastructure is unreliable or of poor quality then the project will be less likely to go ahead.

policy options for technology development, uptake and transfer

Given the type and range of barriers to the widespread development, uptake and transfer of energy efficient and low emission technologies, governments have a key role to play in overcoming these barriers and establishing environments that are conducive to the development and transfer of these technologies in both the public and private sectors. Here, a portfolio of policy options that affect both the demand and supply side will be required.

Policies to encourage the development of new technologies include funding for research, development and deployment projects, strategic research partnerships between government and industry, assigning appropriate intellectual property rights and education and training initiatives. Wide ranging but targeted R&D programs spread risk and potentially increase the economic efficiency of future abatement responses (assuming successful innovation) by providing greater opportunities for low cost abatement across sectors and thereby reducing the overall cost of abatement. R&D on adaptation technologies and management strategies will also be an important component in achieving economic efficiency in the long run given that even immediate and significant emissions abatement would not avoid the impacts of climate change completely, particularly in the short to medium term.

The uptake of technologies can be supported through the introduction of market based instruments, such as carbon penalties or emissions trading, which increase the relative costs of using emission intensive technology. Financial incentives, performance and emissions standards and information programs can also be used to encourage the use of energy efficient and low emission technologies.

Developing economies, however, can lack the institutional capacity to develop and implement certain relevant regulations efficiently and effectively (USAID 2007). The establishment of regional forums for discussing legislation and policy implementation and training for personnel can help to improve policy and regulatory frameworks and build the capacity and knowledge base of regulating bodies, enabling the adoption of relevant laws to be translated into actions that reduce emissions.

For technology to play a significant role in reducing global energy use and emissions, the uptake of energy efficient and low emission technologies and measures will need to be widespread in both developed and developing economies. As

the majority of energy R&D currently takes place in a select number of developed economies, it is important that suitable mechanisms are in place to facilitate both the transfer to, and adoption of these technologies in, developing economies. Participation in international collaborative technology forums such as APEC, the Asia Pacific Partnership on Clean Development and Climate Change (AP6), the Methane to Markets Partnership, the Carbon Sequestration Forum, the Renewable Energy and the Energy Efficiency Partnership and the International Partnership for Hydrogen are important forums for enabling the transfer of technology and information between economies, building capacity and minimising the duplication of research efforts.

APEC can continue to play an active role in reducing barriers to the development and uptake of energy efficient and renewable energy technologies and in developing appropriate funding models through the Energy Working Group, Business Advisory Council, APEC committees and senior officials and leader meetings and processes. Appropriate levels and methods of funding for capacity building and technology development and transfer will differ between APEC economies depending on individual country circumstances. In some economies, direct government funding for technology research, development and demonstration in collaboration with industry partners will be the preferred policy approach. However, in other economies, revenue from implementation of market based instruments to encourage greenhouse gas abatement may be used to fund technology development, demonstration and transfer.

3

benefits of cleaner and advanced technologies

The APEC forum and its associated working groups and processes provide rich opportunities for collaboration on climate change related issues, including technology development and transfer. In this chapter the energy consumption and emissions impacts of a concerted collaborative effort by APEC economies to develop and transfer cleaner, more advanced, energy efficient and low emissions energy sources and technologies are assessed using ABARE's general equilibrium model of the world economy, GTEM. Projections from an illustrative **enhanced technology scenario** are compared against **reference case** projections.

scenario descriptions

reference case scenario

The reference case is a set of projections of regional and global economic growth, population levels, productivity improvements, industry growth, energy consumption and greenhouse gas emissions to 2050. The projection period to 2050 is chosen for illustrative purposes. The reference case aims to reflect a world in which technological development and government policies progress along their expected pathways given the assumption that there is no implementation of any significant climate change policies. A moderate level of technological change is assumed in the reference case across all industries, in line with forecasts by the International Energy Agency, the US Energy Information Administration and various other government and peer reviewed literature sources. There are assumed to be no significant breakthroughs in the cost of supplying renewable and nuclear energy in the reference case.

enhanced technology scenario

In the enhanced technology scenario a concerted and collaborative effort across APEC economies is assumed to occur from 2009 to accelerate the development, uptake and transfer of advanced energy efficient and low emission technologies and energy sources, beyond that which is projected to be achieved

under current and expected policy settings in the reference case. Collaborative action on technology development and transfer in APEC economies is assumed to occur in all sectors across the economy, including electricity, transport, residential, aluminium, cement, mining, iron and steel, wood, pulp and paper, chemical and plastics production, services and agriculture. Other parts of the world are also assumed to benefit from the development of advanced technologies and processes driven by cooperation with APEC economies on technology.

The degree of technological uptake assumed in this analysis differs between regions and industries, reflecting differences in: the current level of technological development; levels of economic development; differences in access to capital, other inputs and skilled labour; variations in economic structure and energy prices; infrastructure requirements and the rate of technology turnover.

The assumed technological development pathways in this analysis are consistent with addressing other concerns, such as energy security, environmental amenity and economic and social development needs.

The enhanced development and uptake of these lower emission technologies and measures is assumed to be achieved through a number of complementary and interactive country, regional and APEC-wide policies. Accelerated technology development is assumed to be driven through incentives to encourage greater levels of R&D in technologies, such as research grants, improved intellectual property rights and strategic partnerships. Increased uptake of available technologies can also be encouraged through performance or emission standards, national campaigns to increase awareness, carbon pricing and the introduction of financial tools to improve competitiveness.

Policies that directly target the uptake of advanced technologies will also provide further incentives to develop more advanced and cost effective technologies. Considerable efforts to build capacity throughout the region and transfer technologies are also assumed to be undertaken.

In table 1 the technological development pathway assumed in the enhanced technology scenario is illustrated.

table 1 **technology development in the enhanced technology scenario**

sector	technology pathway	key technologies
electricity generation	earlier development, lower costs and increased uptake of advanced non fossil fuel power plants and more efficient new fossil fuel generation than in the reference case	solar photovoltaic generation, wind, biomass, waste, nuclear power, IGCC, IGCC biomass, NGCC, hybridised gasification coal and gas plants
	utilisation of carbon capture and storage technologies on all new coal and gas fired electricity generation plants from 2020 in developed and transition economies; from 2025 in China and from 2035 in lower income APEC economies	carbon capture and storage
road transport	earlier and increased uptake of more energy efficient technologies than in the reference case	advanced internal combustion engines and hybrid vehicles, improvements in engine design and materials
	increased uptake of biofuels achieved through technology development	advanced biofuels
water, air and rail transport	earlier development and increased uptake of more energy efficient technologies than in the reference case	advanced aerodynamic structures, advanced diesel propulsion systems, high speed and electric trains and development of larger vehicles to increase passenger and freight intensity
residential and commercial sectors	earlier and increased uptake of more energy efficient and alternative energy technologies than in the reference case	compact fluorescent globes, light emitting diodes, improved building design and insulation, ground source and absorption heat pumps, solar heating/ hot water/cooling systems, more efficient refrigerators and ventilation systems, magnetic induction cooktops, high performance gas burners and microwave convection ovens
cement	earlier and increased uptake of more energy efficient technologies and greater uptake of blended cements and development of new cement types	fluidised bed kiln technology, blended cements, preheaters and precalciners, dry raw feed preparation, geopolymers

continued...

table 1 **technology development in the enhanced technology scenario**
continued

sector	technology pathway	key technologies
iron and steel	earlier and increased uptake of more energy efficient technologies and higher recycling rates than in the reference case	single vessel smelt reduction and strip casting technology, increased recycling rates
chemicals, rubber and plastics	earlier and increased uptake of more energy efficient technologies than in the reference case	membrane separation technology, advanced steamers and boilers, better material design and heat recovery technologies, advances in refrigeration, reduced process leaks, optimising furnace temperatures, reducing run times
wood, pulp and paper	earlier and increased uptake of more energy efficient technologies, utilisation of alternative fuels and higher recycling rates than in the reference case	fluidised bed technology, high intensive drying techniques, black-liquor gasification
primary aluminium	improvements in energy efficiency and reductions in fugitive emissions relative to the reference case	advanced cathode designs, carbothermic technology, inert anodes
mining	improvements in energy efficiency and reductions in fugitive emissions relative to the reference case	technologies to reduce methane pipeline losses, improvements in grinding technologies and the increased implementation of control based management practices
agriculture	improvements in energy efficiency and reductions in fugitive emissions relative to the reference case	utilisation of fugitive abatement technology, increased livestock productivity, improved feed quality, more efficient fertiliser and irrigation practices, anaerobic digesters, aerobic manure composting
other industries	earlier development and increased uptake of more energy efficient technologies than in the reference case and greater switching to lower emissions energy sources	more advanced boilers, motors and steam systems, fluidised combustion technology, low emission energy sources

reference case – projected impacts of continuing along current pathways

energy consumption to increase considerably – fossil fuels to dominate

APEC economies

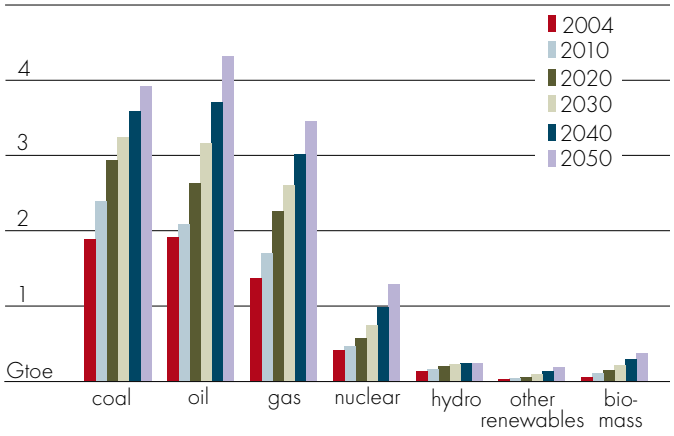
In the reference case total primary energy consumption in APEC economies is projected to increase by nearly 140 per cent from 5.8 gigatonnes of oil equivalent (Gtoe) in 2004 to 13.7 Gtoe in 2050 (figure C). This is driven by relatively strong economic growth and continued population growth across many APEC economies.

Fossil fuels are projected to remain the dominant source of energy consumption in APEC in the reference case. Growth in fossil fuels is driven primarily by increases in demand for: oil based petroleum in the transport sector, coal in the electricity sector and gas in the electricity, industry and residential sectors. At 2050, oil, coal and gas are projected to account for 31 per cent, 29 per cent and 25 per cent respectively of APEC primary energy consumption in the reference case (table 2).

table 2 **share of fuel type in APEC primary energy consumption**
reference case

	2004	2050
	%	%
coal	33	29
oil	33	31
gas	24	25
nuclear	7	9
hydro	2	2
biomass	1	3
other renewables	0.3	1

fig C **APEC primary energy consumption**
reference case



world

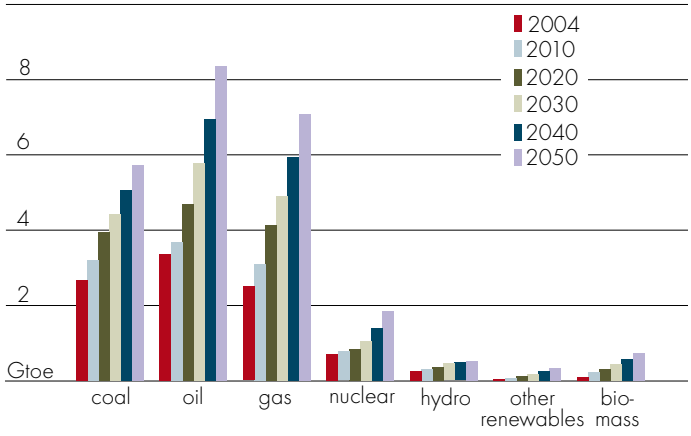
In 2004, APEC economies contributed around 60 per cent of global primary energy consumption. Given the large contribution of APEC economies to global energy consumption, global energy consumption patterns will be driven in large part by actions in APEC economies. Global energy consumption is projected to increase by 156 per cent from 9.6 Gtoe in 2004 to 24.6 Gtoe in 2050 (figure D).

table 3 **share of fuel type in global primary energy consumption**
reference case

	2004	2050
	%	%
coal	28	23
oil	35	34
gas	26	29
nuclear	7	8
hydro	3	2
biomass	1	3
other renewables	0.4	1

Fossil fuels are also projected to dominate global energy consumption. In 2050 the projected shares of different energy types are: oil (34 per cent), coal (23 per cent), gas (29 per cent), hydroelectricity (2 per cent), nuclear (8 per cent), biomass (3 per cent) and other renewables (1 per cent) (table 3).

fig D **global primary energy consumption**
reference case



electricity and heat generation to rise rapidly – high emissions intensive fuels to dominate

APEC economies

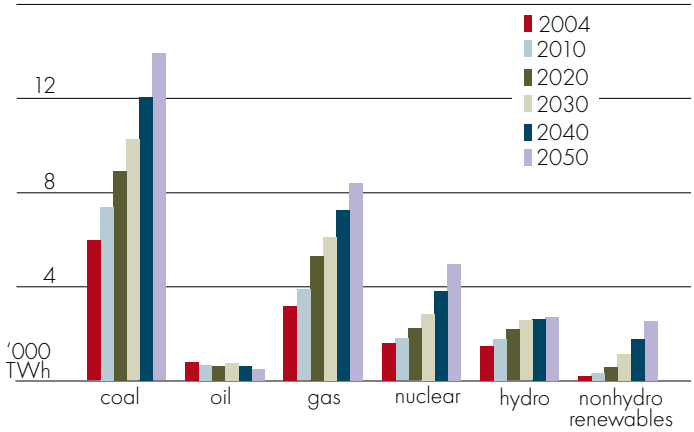
Electricity and heat generation is projected to increase by about 150 per cent in APEC economies from 13 150 TWh in 2004 to 33 000 TWh in 2050 in the reference case (figure E).

Fossil fuels are projected to remain the dominant source of electricity and heat generation in APEC economies throughout the projection period given their lower relative costs and availability. The share of coal and oil in APEC electricity and heat generation is projected to decline from 45 per cent and 6 per cent to 42 per cent and 1 per cent respectively between 2004 and 2050. However, the share of gas and nonhydro renewables is projected to increase from 24 per cent and 1 per cent respectively in 2004 to 26 per cent and 7 per cent respectively in 2050 (table 4).

table 4 **share of fuel type in APEC electricity and heat generation**
reference case

	2004	2050
	%	%
coal	45	42
oil	6	1
gas	24	26
nuclear	12	15
hydro	11	8
nonhydro renewables	1	7

fig E **APEC electricity and heat generation**
reference case



world

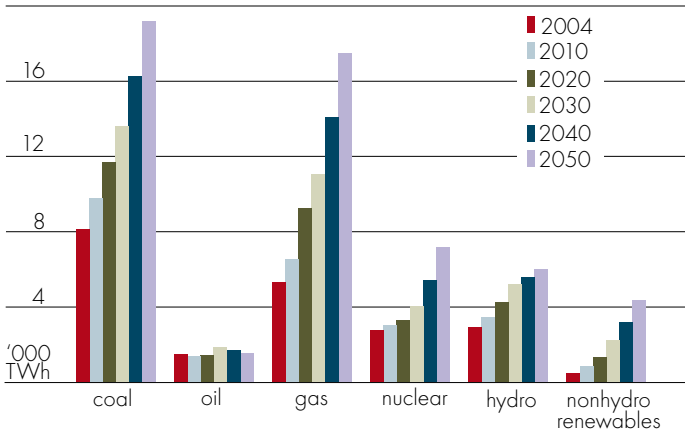
Global electricity and heat generation is projected to increase by about 165 per cent from about 21 000 TWh in 2004 to 55 600 TWh in 2050 in the reference case (figure F).

table 5 **share of fuel type in global electricity and heat generation**
reference case

	2004	2050
	%	%
coal	39	35
oil	7	3
gas	25	31
nuclear	13	13
hydro	14	11
nonhydro renewables	2	8

Coal is projected to remain the dominant source of global electricity and heat generation. However, gas and nonhydro renewables are projected to increase their shares considerably. In 2050 the projected shares of different energy types are: coal (35 per cent), gas (31 per cent), oil (3 per cent), hydroelectricity (11 per cent), nuclear (13 per cent) and nonhydro renewables (8 per cent) (table 5).

fig F **global electricity and heat generation**
reference case



greenhouse gas emissions to increase relatively unabated

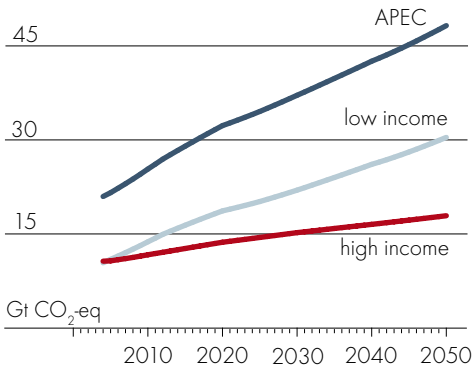
Projections of greenhouse gas emissions in this chapter do not include emissions from land use change and forestry.

APEC economies

In the reference case, greenhouse gas emissions in APEC are projected to increase from about 20.9 Gt CO_2-eq in 2004 to 48.2 Gt CO_2-eq in 2050, rising by 130

per cent over the period (figure G). Increasing demand for electricity, transport, agricultural products, other energy services and other emissions intensive goods and services are the primary drivers of growth.

fig G **greenhouse gas emissions in APEC economies** reference case

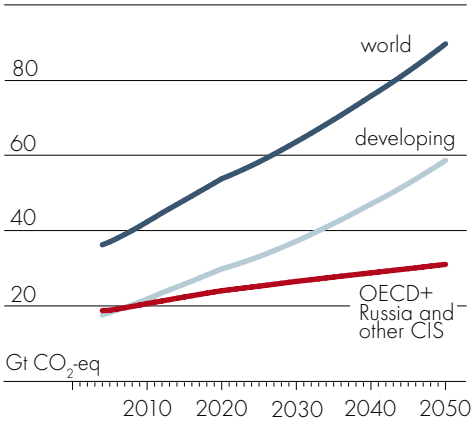


High income and low income economies in APEC emitted about 10.6 Gt CO_2-eq and 10.3 Gt CO_2-eq respectively in 2004. In the reference case, emissions in high income APEC economies are projected to increase by about 1.1 per cent a year between 2004-50 rising to 17.8 Gt CO_2-eq in 2050 (a 69 per cent increase over the period 2004-50). However, in low income APEC economies, emissions are projected to grow at a considerably faster rate of around 2.4 per cent a year over the period 2004-50, increasing to 30.3 Gt CO_2-eq in 2050 (a 194 per cent increase). This strong growth in emissions in low income APEC economies is driven by continued population growth and significantly higher projected economic growth relative to high income APEC economies.

world

Global greenhouse gas emissions in the reference case are projected to increase by about 148 per cent from 36.2 Gt CO_2-eq in 2004 to 89.6 Gt CO_2-eq in 2050 (figure H). Growth in emissions from developing economies is projected to be significant, with emissions from developing economies projected to increase by about 235 per cent between 2004 and 2050. Emissions from OECD plus the Russian Federation and other CIS economies are projected to increase by about 66 per cent between 2004 and 2050.

fig H **global greenhouse gas emissions** reference case



enhanced technology scenario – benefits of APEC technology collaboration

energy consumption – a transition to cleaner fuels and achieving 'more with less'

APEC economies

In the enhanced technology scenario the uptake of more energy efficient end-use and production technologies is projected to slow the growth in energy consumption considerably in APEC economies. Primary energy consumption in APEC is projected to increase by about 62 per cent between 2004 and 2050, reaching 9.3 Gtoe in 2050 (figure I). Compared with the reference case, primary energy consumption in the enhanced technology scenario is projected to be about 32 per cent lower in APEC economies at 2050.

In the short to medium term, the majority of reductions in energy consumption and emission reductions in the enhanced technology scenario, relative to the reference case, are assumed to be achieved through government efforts to reduce barriers to the uptake of currently available and best practice energy efficient technologies. In the longer term, the development and widespread deployment of advanced energy efficient and low emission technologies and energy sources will be critical in achieving significant reductions in energy use and emissions.

fig I **APEC primary energy consumption**
enhanced technology scenario

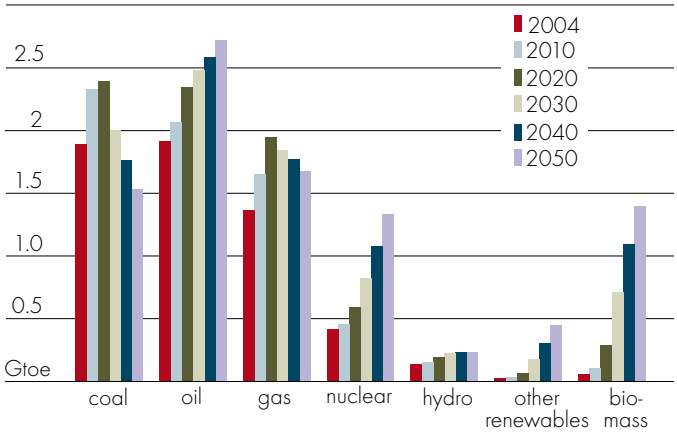


fig J **change in APEC primary energy consumption at 2050** enhanced technology scenario – relative to the reference case

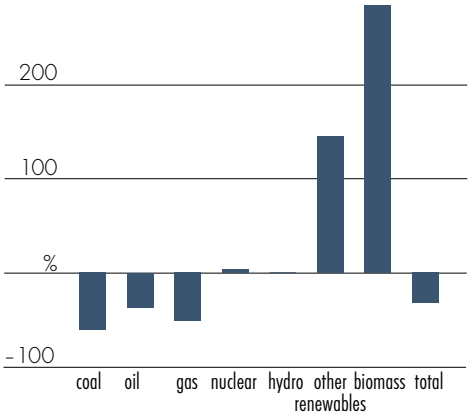


table 6 **share of fuel type in APEC primary energy consumption** enhanced technology scenario

	2004	2050
	%	%
coal	33	16
oil	33	29
gas	24	18
nuclear	7	14
hydro	2	3
biomass	1	15
other renewables	0.3	5

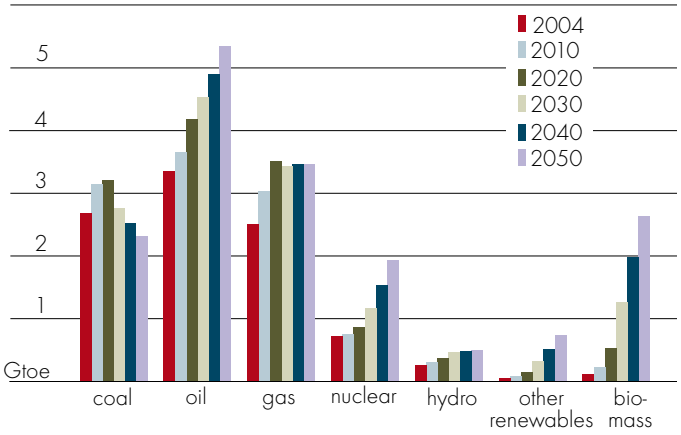
Consumption of fossil fuels is projected to fall considerably in the enhanced technology scenario relative to the reference case (table 6). There are also significant increases in the share of cleaner technologies, including carbon capture and storage and nonhydro renewables, in the electricity sector. There is also a projected increase in the consumption of biofuels in the transport sector.

The reduction in oil and other fossil fuel consumption in APEC economies in the enhanced technology scenario, relative to the reference case, will have beneficial impacts on energy security in the APEC region (figure J). For example, it is projected that APEC economies will consume about 37 per cent less oil at 2050 in the enhanced technology scenario, compared with reference case levels.

world

In the enhanced technology scenario, collaborative technology partnerships in APEC economies are projected to lead to widespread uptake of more energy efficient technologies globally. In the enhanced technology scenario, global energy consumption is projected to be about 31 per cent below reference case levels at 2050. However, global energy consumption is still projected to increase by about 76 per cent over the period 2004–50, reaching about 16.9 Gtoe in 2050 (figure K).

fig K **global primary energy consumption**
enhanced technology scenario



On average in the enhanced technology scenario, global fuel consumption is projected to be more efficient, and use less emissions intensive technologies and energy sources at 2050 than in the reference case (table 7).

fig L **change in global primary energy consumption at 2050** enhanced technology scenario – relative to the reference case

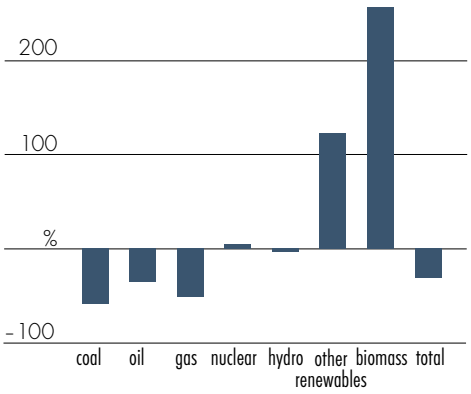


table 7 **share of fuel type in global primary energy consumption**
enhanced technology scenario

	2004 %	2050 %
coal	28	14
oil	35	32
gas	26	20
nuclear	7	11
hydro	3	3
biomass	1	16
other renewables	0	4

The projected reduction in oil and other fossil fuel consumption throughout the world in the enhanced technology scenario, relative to the reference case, will have favourable impacts on global energy security (figure L). For example, it is projected that global consumption of oil and gas will be about 36 per cent and 51 per cent respectively below reference case levels at 2050 in the enhanced technology scenario.

electricity and heat generation – decarbonising the electricity supply sector

APEC economies

In the enhanced technology scenario, the uptake of energy efficient technologies in end use sectors results in a considerable decline in demand for electricity generation. By 2050, electricity and heat generation in APEC economies is about 36 per cent lower in the enhanced technology scenario, relative to the reference case. However, electricity and heat generation in APEC is still projected to increase by about 61 per cent between 2004 and 2050 to around 21 200 TWh at 2050 in the enhanced technology scenario (figure M).

In the enhanced technology scenario, electricity and heat generation in APEC is projected to be significantly decarbonised by 2050. This occurs as a result of signifi-

fig M **APEC electricity and heat generation**

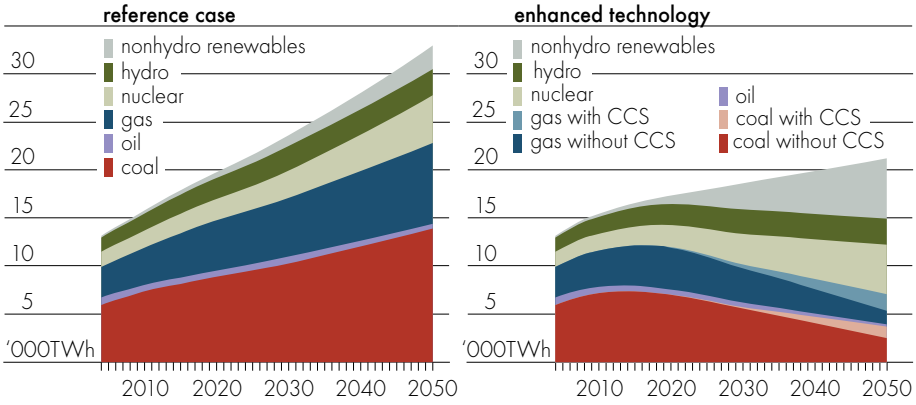


fig N **change in APEC electricity and heat generation at 2050** enhanced technology scenario – relative to the reference case

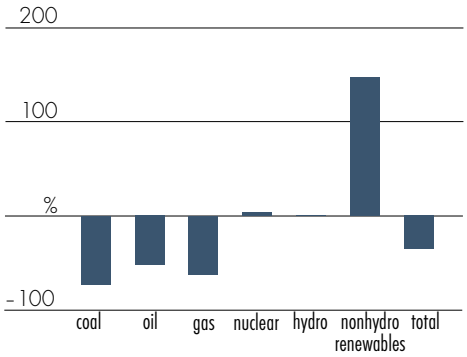


table 8 **share of fuel type in APEC electricity and heat generation** enhanced technology scenario

	2004 %	2050 %
coal without CCS	45	12
coal with CCS	0	6
oil	6	1
gas without CCS	24	7
gas with CCS	0	8
nuclear	12	24
hydro	11	13
nonhydro renewables	1	30

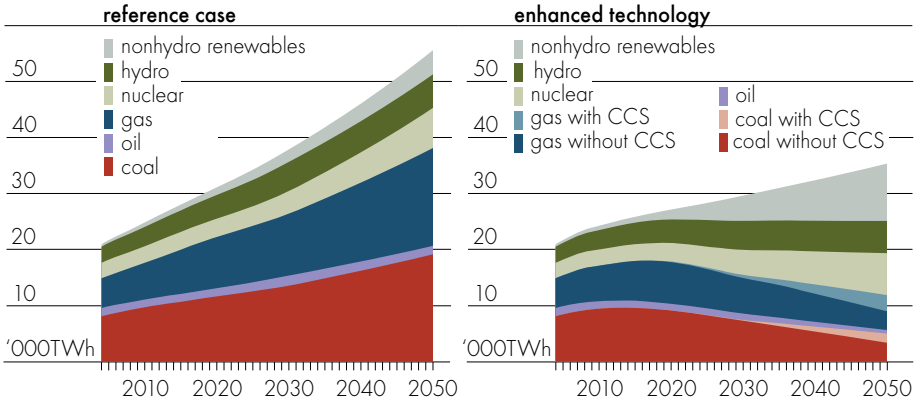
cant uptake of CCS on new coal and gas fired electricity beyond 2020 and a shift to nuclear and nonhydro renewable electricity generation technologies in response to improvements in the competitiveness of these technologies (table 8). By 2050 about 41 per cent of the remaining fossil fuel electricity plants in APEC are projected to use CCS. In the enhanced technology scenario, fossil fuels are replaced by nuclear and renewable technologies as the dominant sources of electricity generation.

The projected absolute decline in electricity and heat generation in the enhanced technology scenario, relative to the reference case, reduces the requirement for new electricity generation infrastructure in APEC economies. However, the required mix of electricity generation supply infrastructure changes significantly from the projected reference case mix as a result of the relative increases in generation using carbon capture and storage and nonhydro renewable technologies. For example, it is projected that, in 2050, electricity generation using nonhydro renewables in APEC will be about 155 per cent higher in the enhanced technology scenario than in the reference case (figure N).

world

In the enhanced technology scenario, global electricity and heat generation is projected to be about 36 per cent below reference case levels at 2050. However, global electricity and heat generation is still projected to increase by about 69 per cent from around 21 000 TWh in 2004 to 35 400 TWh in 2050 (figure O).

fig O **world electricity and heat generation**



Globally, electricity and heat generation is projected to become significantly decarbonised by 2050. By that time, about 79 per cent of global electricity is projected to be generated using carbon capture and storage, nuclear or renewable technologies in the enhanced technology scenario (table 9). It is projected that globally, in 2050, electricity and heat generation using coal will be about 74 per cent lower in the enhanced technology scenario than in the reference case (figure P).

fig P **change in global electricity and heat generation at 2050** enhanced technology scenario – relative to the reference case

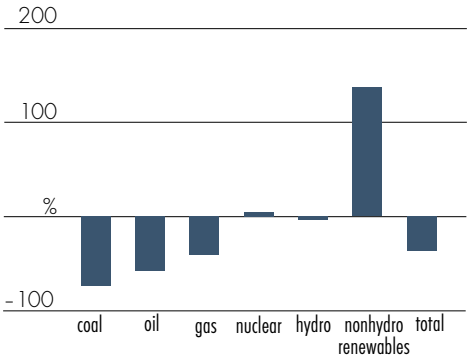


table 9 **share of fuel type in global electricity and heat generation**
enhanced technology scenario

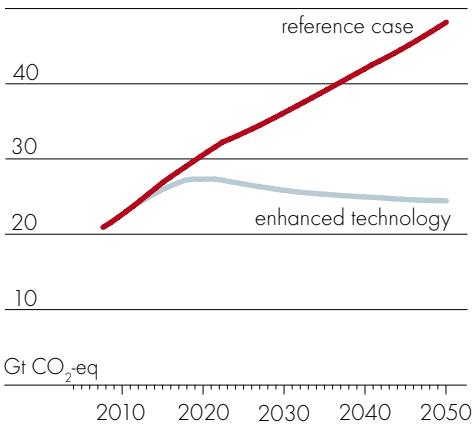
	2004	2050
	%	%
coal without CCS	39	10
coal with CCS	0	5
oil	7	2
gas without CCS	25	9
gas with CCS	0	8
nuclear	13	21
hydro	14	16
nonhydro renewables	2	29

growth in greenhouse gas emissions to fall significantly

APEC economies

In the enhanced technology scenario, the greater uptake of energy efficient and low emission technologies throughout APEC economies is projected to reduce the growth in greenhouse gas emissions in APEC such that emissions are about 49 per cent below reference case levels at 2050 (figure Q). However, greenhouse gas emissions in APEC are still projected to be about 17 per cent higher in 2050 (at 24.4 Gt CO_2-eq) than in 2004 as a result of the strong growth in demand for energy services.

fig Q **APEC greenhouse gas emissions**



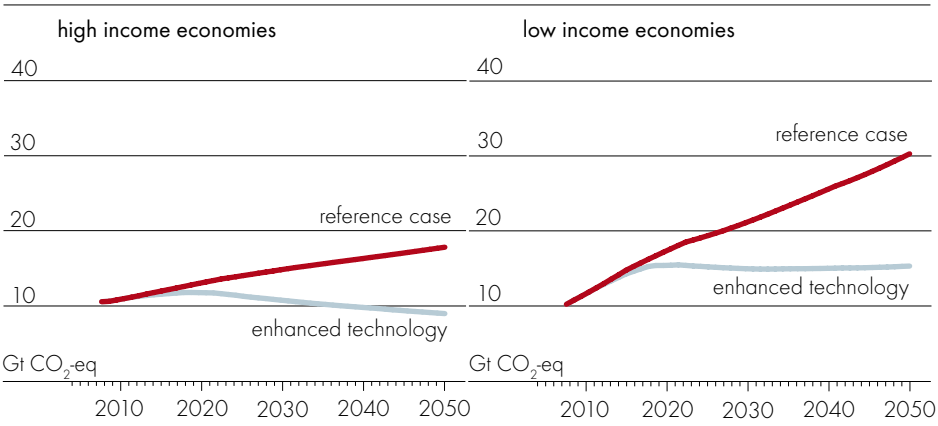
At 2050, greenhouse gas emissions in high income APEC economies are projected to be about 49 per cent below reference case levels (at about 9.0 Gt CO_2-eq) and about 15 per cent below 2004 levels, driven by the enhanced uptake of advanced energy efficient and low emission technologies. In low income APEC economies, emissions are also projected to decline by about 49 per cent relative to the reference case at 2050 in the enhanced technology scenario. However, in that scenario, emissions in low income APEC economies are projected to increase by 49 per cent between 2004 and 2050, rising to 15.4 Gt CO_2-eq in 2050, driven by strong growth in demand for energy services (figure R).

electricity and heat generation emissions

APEC economies

In the enhanced technology scenario, emissions from electricity and heat generation in APEC are projected to fall considerably, declining by about 61 per cent relative to 2004 levels in 2050 (at 2.7 Gt CO_2-eq). Abatement in the electricity sector is driven by the significant reduction in electricity demand and a consider-

fig R **greenhouse gas emissions in APEC, by income group**



able decline in the emissions intensity of electricity generation as a result of the widespread uptake of carbon capture and storage technologies and switching to lower emission technologies, particularly to nonhydro renewables (figure S).

emissions abatement, by end use sectors

APEC economies

In 2004 the major contributors to APEC end use emissions* were the transport sector, key industry sector (iron and steel, nonmetallic minerals, mining, wood pulp and paper, primary aluminium and chemicals, rubber and plastic) and the agriculture sector, which contributed 20 per cent, 31 per cent and 10 per cent respectively (figure T). In the reference case the contribution of the transport sector to end use emissions is projected to increase to 25 per cent by 2050 as a result of strong

*Electricity emissions are allocated to end users.

fig S **emissions from electricity and heat generation in APEC**

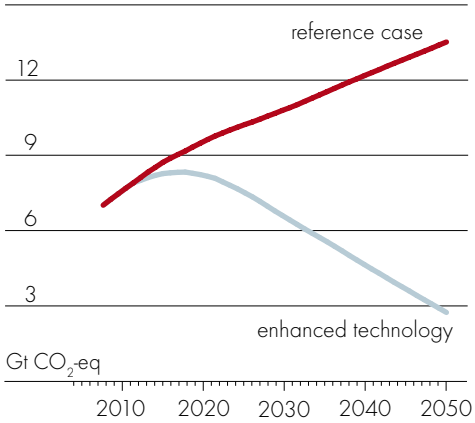
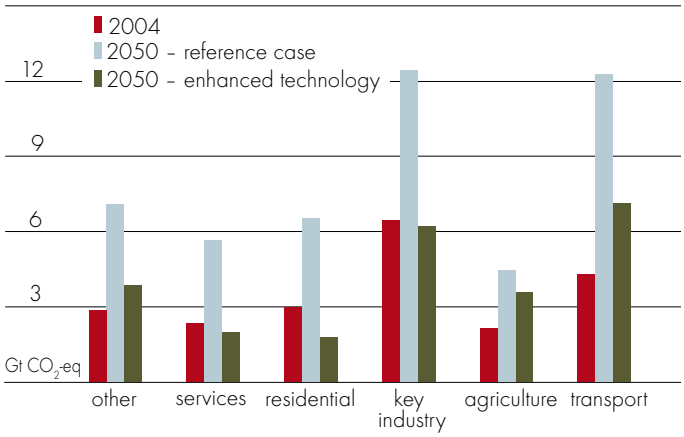
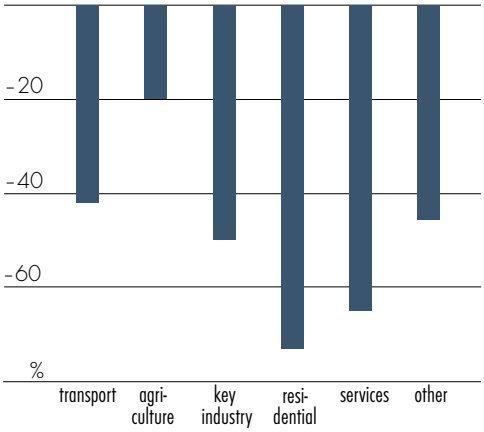


fig T **APEC sectoral emissions**



demand for transport services in low income APEC economies and the continued reliance on petroleum fuelled internal combustion engines.

fig U **change in APEC sectoral emissions at 2050** enhanced technology scenario – relative to the reference case



Note: electricity emissions have been allocated to end users

In the enhanced technology scenario at 2050, emissions from key industries, agriculture and transport, are projected to account for about 69 per cent of APEC emissions or 17.0 Gt CO_2-eq, which is equivalent to about 81 per cent of total APEC emissions in 2004. To achieve reductions in APEC emissions below 2004 levels requires significant additional abatement, particularly in these three sectors.

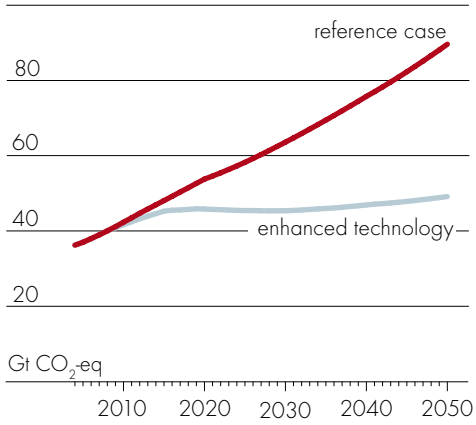
In the enhanced technology scenario, the percentage reduction in sectoral emissions relative to the reference case differs between sectors as a result of variations in: the assumed technological devel-

opment and uptake pathway, technological and fuel source substitution opportunities, growth in sectoral output and the relative position of each sector on their technological frontier. In figure U, the percentage decline in sectoral emissions in APEC in the enhanced technology scenario relative to the reference case is presented.

world

In the enhanced technology scenario the widespread diffusion of energy efficient and low emission technologies globally results in global emissions declining by 45 per cent at 2050 compared with the reference case. Despite this large decline, global emissions are projected to continue to rise in the enhanced technology scenario, increasing by 36 per cent between 2004 and 2050, reaching 49.1 Gt CO_2-eq in 2050 (figure V).

fig V **global greenhouse gas emissions**



4

mitigation potential in forestry

Mitigation activities in the forestry sector, such as afforestation, reforestation and reduced deforestation, can contribute to the removal of carbon dioxide from the atmosphere, with the potential to deliver environmental, social and economic benefits. In this chapter, the emissions abatement potential of changes in deforestation rates in a range of APEC economies is assessed.

forest resources in the APEC region

Native and managed forests cover more than a third of the APEC region. In 2004, according to FAO (2007) estimates, the forest area in APEC was 2145 million hectares, accounting for about 54 per cent of the world's total forest area. In that year, the forest area in four APEC economies – Canada, China, the Russian Federation and the United States – was 1619 million hectares, accounting for more than 40 per cent of the world's total forest area. Between 2000 and 2005 the APEC region as a whole experienced a net increase in forest area of about 1.5 million hectares a year. This compares with a net loss of forest cover of slightly over 0.5 million hectares a year in the region during the 1990s (FAO 2007).

The recent increase in forest cover in the APEC region was largely the result of an increase of more than 4 million hectares a year in China, where investment in forest plantations has been significant. Several other APEC economies, namely Viet Nam, the United States, Chile and New Zealand, also increased their forest area between 2000 and 2005. Despite these increases, many other APEC economies had net losses in forest area during the period, primarily as a result of the expansion of agriculture, infrastructure and logging. Between 1990 and 2005, the largest decline in forest cover in the APEC region occurred in Indonesia (about 1.9 million hectares a year), followed by Mexico (FAO 2007). Several APEC economies are losing forests at rates exceeding 1.5 per cent a year; some of the highest rates in the world.

abatement potential in the forestry sector

Carbon sequestration in forestry can play an important role in reducing greenhouse gas emissions through activities such as slowing the rate of deforestation

and degradation (the reduction in forest biomass due to unsustainable harvesting or land use practices), increasing the establishment of forests and improving forest management.

The carbon sequestration benefits vary between regions and for each abatement option in the forestry sector. In the short to medium term, larger gains can be achieved through mitigation options aimed at reducing emission sources, including reduced deforestation and degradation, fire protection and slash burning. In contrast, the carbon sequestration benefits from afforestation (establishing new forests) and reforestation (re-establishing former forests) may take many years to materialise and require considerable upfront investment (Stavins and Richards 2005). In addition, much more land would have to be allocated to establishing new forests to achieve the same amount of carbon sequestration as the carbon released from burning an existing forest of mature trees. Most forest management activities aimed at enhancing sinks require significant upfront investment, and the duration and magnitude of their carbon sequestration benefits differ across regions, types of action and initial condition of the forest.

Apart from carbon sequestration, abatement strategies in the forestry sector can also have positive spinoff effects, including improved supply stability of forest products, better management of protected areas and creation of employment opportunities in rural areas. Therefore, a greater integration of climate change initiatives with other sustainable development programs, particularly those aimed at the conservation of biodiversity, sustainable forest management and control of deforestation, could generate greater mitigation benefits in the long term. Importantly, the investment in forestry related abatement strategies needs to complement, rather than substitute, the effort to reduce fossil fuel emissions in both developed and developing economies.

deforestation and emissions

Globally, deforestation has been one of the key sources of emissions in recent years. Some estimates indicate annual emissions from deforestation at around 18–25 per cent of the anthropogenic emissions of greenhouse gases (Baumert, Herzog and Pershing 2005; FAO 2007; Houghton 2005). The share of emissions from deforestation is higher in developing economies than in developed economies.

Tropical forests constitute less than half of the global forest area, yet they hold about as much carbon in their vegetation and soils as temperate and boreal

forests combined (Houghton 2005). Trees in tropical forests hold, on average, about 50 per cent more carbon per hectare than trees outside the tropics. Consequently, deforestation in the tropics leads to higher releases of carbon dioxide than from nontropical forests on a comparable basis.

Tropical forests are primarily located in developing economies, where higher economic and population growth places considerable pressure on the exploitation of natural forests. Major sources of tropical deforestation include the permanent conversion of forestland to agricultural or other uses and the removal of forests for timber production.

forest policies in the APEC region

Many economies in the APEC region have relatively sound legislative and policy foundations from which to implement sustainable forest management policies that also support mitigation of greenhouse gases. A number of economies, including China, the Philippines and Thailand, have significantly reduced their deforestation rates in response to environmental concerns. In the United States, several government programs support the establishment, retention and improved management of forest cover on private lands, often of marginal agricultural quality. In addition to forest plantations, China has also initiated a range of other policies to enhance the capacity for carbon sequestration in forestry, including natural forest protection, conversion of cultivated land to forestland or grassland and pasture restoration and protection.

Indonesia has had one of the largest declines in forest cover over the past decades. To improve forest management and address land tenure issues, the Indonesian Government introduced an initiative in 2007 that outlines the rules and guidelines for forest management systems based on the principles of good governance, local community development, and improving the investment climate (PEACE 2007). To promote compliance with the principles of sustainable forest management, Indonesia has also developed criteria and indicators for auditing the operations of forest concessionaires.

In 2007, Australia launched a Global Initiative on Forests and Climate, which provides support for the key forestry based mitigation strategies, such as reducing deforestation, planting new forests and investing in sustainable forest management practice (Australian Government 2007). This initiative aims to bring together both developed and developing economies and international organisations to deliver

practical action that will substantially reduce global greenhouse gas emissions. Actions include building developing economies' technical capacity to assess their forest resources, putting in place effective regulatory and law enforcement arrangements to protect forests, promoting the sustainable use of forest resources and diversifying the economic base of forest dependent communities. Building capacity to develop robust monitoring and accounting systems for assessing changes in forest carbon and forest cover will also be a key focus area.

impact of reduced deforestation – the case of tropical APEC economies

As discussed earlier, reducing deforestation rates and/or improving forest management practices have substantial carbon dioxide abatement potential, regionally as well as globally. The purpose of the analysis presented here is to examine the medium to long term carbon dioxide mitigation potential of certain changes in deforestation rates in tropical south east Asian APEC economies.

To quantify the carbon dioxide mitigation potentials in the tropical APEC forestry regions, two scenarios are considered – the reference case scenario reflecting current policy settings, and an illustrative alternative scenario. Under the reference case scenario, the historical trends in forest cover change in various economies over the past two decades were maintained throughout the projection period to 2050. In the illustrative alternative scenario, the assumed deforestation rates in the reference case scenario were halved for tropical south east Asian APEC member economies. Reduced deforestation is assumed to be implemented progressively from 2009. For the reduced deforestation under the alternative scenario, the tropical south east Asian APEC region was chosen because of its current high rate of deforestation and the significant potential for carbon absorption in tropical forests.

The two scenarios were simulated using ABARE's global trade and environment model, GTEM, that represents various land classes as well as forest inventory in terms of forest stand, tree age and management practices (Ahammad and Mi 2005). The projected differences in the forest carbon stocks under the two scenarios were taken to represent the carbon dioxide mitigation benefits of the assumed reduction in deforestation. The estimates presented here should be treated as illustrative.

table 10 **net annual change in emissions from forestry in the APEC region**
reference case **a**

	2010 Mt CO_2	2030 Mt CO_2	2050 Mt CO_2
APEC region			
north America **b**	-239	-373	-707
Russian Federation	44	19	-78
north Asia **c**	-94	-395	-543
south east Asia **d**	129	346	230
all APEC economies **e**	-22	-72	-264

a Negative numbers indicate carbon sinks. **b** Includes the United States, Canada and Mexico. **c** Includes China, Japan and Republic of Korea. **d** Includes Indonesia, Malaysia, the Philippines, Thailand and Viet Nam, as well as Myanmar, Laos and Cambodia. **e** Excludes APEC member economies of Brunei Darussalam, Chile, New Zealand, Papua New Guinea, Peru and Chinese Taipei.
Source: ABARE projections.

The projected net emissions of carbon dioxide from forestry under the reference case scenario are provided for the APEC region in table 10 (a negative entry in the table implies net carbon sinks). As can be seen from the table, there is a wide variation in potential net emissions of carbon dioxide from forestry, across economies as well as over time. Nonetheless, the size of the sink potential in the United States and China, in particular, are projected to make APEC as a whole a net sink in the future.

table 11 **abatement potential in forestry in the tropical south east Asian APEC region**
reduced deforestation scenario

	net annual change in emissions Mt CO_2	relative to reference case scenario %
2030	120	30
2050	160	70

Source: ABARE projections

Under the alternative scenario, halving the reference case scenario rates of deforestation in the tropical south east Asian APEC region is projected to result in about a 70 per cent fall in forestry related emissions in south east Asia relative to the reference case at 2050 (table 11). This represents a reduction of about 160 million tonnes of carbon dioxide emissions from forest activities in the region under the alternative scenario at 2050. The abatement potential in the region under the alternative scenario is projected to increase gradually over time.

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