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- Analyses of oil pricing and climate change measures under new circumstances -

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"Asia/World Energy Outlook 2015" team members

Research Advisor	Kokichi ITO

The Energy Data and Modelling Center (EDMC)

Director	Yukari YAMASHITA
Group Manager	Akira YANAGISAWA
Senior Economist	Yuji MATSUO
Senior Economist	LIM Eui Soon
Senior Economist	Momoko AOSHIMA
Senior Economist	Ryouhei IKARII
Senior Economist	LU Zheng
Economist	Souhei IWATA
Economist	Ryo ETO
Economist	Yasuaki KAWAKAMI
Economist	Kodai TOMOKAWA
Economist	Miyuki TSUNODA

Global Environment and Sustainable Development Unit

Managing Director	Akihiro KUROKI
Assistant Director	Koichi SASAKI
Group Manager	Takahiko TAGAMI

New and Renewable Energy and International Cooperation Unit

Group Manager	Yoshiaki SHIBATA
Researcher	KAN Sichao

Strategy Research Unit

Managing Director and Chief Economist	Ken KOYAMA
Group Manager	Tomoko MURAKAMI
Researcher	Kei SHIMOGORI
Researcher	Fumihiro OCHI
Researcher	Atsuhiko SUZUKI

Fossil Fuels and Electric Power Industry Unit

Group Manager	Yoshikazu KOBAYASHI
Group Manager	Tetsuo MORIKAWA
Group Manager	Atsuo SAGAWA
Senior Researcher	Hiroshi HASHIMOTO
Researcher	Yu NAGATOMI

Councillor	Rejean CASAUBON

Foreword

The global energy environment has changed dramatically since only a little more than one year ago. Doubts have arisen about whether emerging countries would drive the acceleration of global economic growth in the near future. In Greece, default, unexpected in any industrial country, has become a real fear. Confrontation or attempts to change the status quo with the backing of "power", in such regions as Ukraine, the Middle East and Asia have remained a great matter of concern. We have also seen historic developments for détente, including an agreement on Iran's nuclear problem and the normalization of U.S. – Cuban relations. But signs of improvements in U.S. – Iran relations and the very recently started bombing in the Middle East by Russia are feared to trigger new disputes in the Middle East.

If the oil supply-demand balance were tight, the deterioration of relations between Western countries and Russia, the geopolitical tensions growing through terrorist attacks by the Islamic State and other militants, or the Arab League forces' intervention in Yemen plagued with a civil war could have stimulated a fear of energy supply interruption and triggered remarkable hikes in international oil prices. Actually, however, crude oil prices have halved from the latest peak recorded in June 2014 due to growing U.S. unconventional oil production, a strategy of the Organization of the Petroleum Exporting Countries (OPEC) giving priority to maintaining its market share and economic deceleration in emerging and developing countries.

Oil prices had been gradually rising over some 10 years, including some periods of pauses in hikes, before staying high until recently. Analysts may be divided over whether the fallback from levels above $100 per barrel should be interpreted as symbolizing an end to the so-called Super Cycle, in which commodity prices continued rising over a long term due to structural factors, or as a simple temporary adjustment. The division leads to differences over future crude oil prices. Regardless of the interpretation for the fallback, it is very difficult now to foresee oil prices, particularly for the distant future. As crude oil prices have plunged more rapidly than expected at this time, it has grown more difficult to forecast future oil prices.

Excessive crude oil price fluctuations induce unacceptable income transfers between oil producing and consuming countries. If the distribution of wealth through income transfers is excessive, its negative effects may endanger the world's sustainable development over a medium to long term. Any great price instability as well as low price levels may impose unignorable negative effects on the energy system and on the world economy through incomplete supply-demand adjustment. We must be alert to this risk.

Global energy system components, whether they are on the supply side or the demand side and whether they are hardware or software including institutions, characteristically feature long lead and life times. As they are upgraded, preliminary investment grows larger. Large-scale, long-term investment is based on future prospects. If confidence in future prospects declines due to an excessive increase in uncertainties, investors, excluding very risk-preferring ones, may attempt to reduce initial investment. If they put off their supply capacity expansion or continue to select cheap, inefficient equipment, the world may plunge into a severe situation where the energy supply-demand balance may collapse.

Regarding uncertainties, we must touch upon how to address the climate change problem that cannot be separated from energy problems. At the 21st Conference of Parties to the United Nations Framework Convention on Climate Change, or COP21, opening in Paris in late 2015, more countries will be requested to participate in an agreement under a bottom-up approach, giving top priority to the effectiveness of any agreement. Over the past quarter century, multilateral negotiations have made a rough going with many countries pursuing ideals, bringing about an unintended result in which efforts to reduce the emissions of greenhouse gases including energy-related carbon dioxide have been stalled. COP21 should depart from the stalemate and make a breakthrough.

However, COP21 may not necessarily solve all problems. In fact, scientific knowledge is still limited about the difficult challenge of climate change that will face the human race over many generations or a very long term. But we should not be allowed to abandon the emission-reducing efforts for the reason that the climate system has yet to be clarified. As well, it may not be wise to decide measures for implementation over a long term in a very quick, biased manner.

As noted in the fifth climate change assessment report by the Intergovernmental Panel on Climate Change (IPCC), the potential of climate sensitivity or relations between GHG emissions, the atmospheric GHG concentration and temperature hikes has become greater than earlier conceived. It is very important to take maximum advantage of the scientific knowledge available at present to consider the best mix of climate change mitigation and adaptation measures to minimize damage over a long term. Such approach is significant for securing the implementability of these measures and the effectiveness of damage reduction.

In the Asia/World Energy Outlook 2015, or the 10th edition of the series, we attempted to depict the world's long-term energy supply and demand picture based on the latest information and precise analyses as usual. At the same time, we provided an analysis made for presenting a direction in which the world should go in the face of the above two major questions from a realistic point of view. We would be pleased if this latest outlook is able to contribute to accumulating knowledge for contemplating the future of the energy situation plagued with uncertainties.

Tokyo, October 2015

THE INSTITUTE OF ENERGY ECONOMICS, JAPAN

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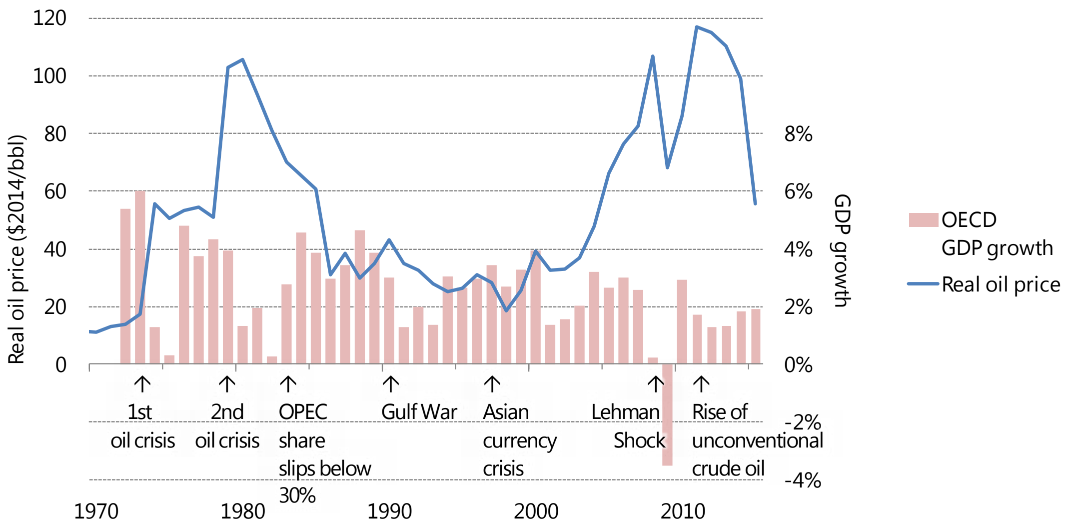
Executive summary

Greatly changed surroundings for international oil market

Why are oil prices attracting attention now?

Oil prices' plunge since the second half of 2014 has led us to recognise the importance of oil prices for global political, economic and energy situations. They not only represent the prices of the world's largest energy source but also serve as a benchmark for natural gas prices mainly in Asia, exerting great influences over the global energy supply-demand balance and options. Fluctuations in prices of the world's largest traded commodity can bring about income and wealth relocations in line with its massive trading volume, working to greatly shake the balance of power in the world economy and in international politics. Oil prices plunged after remaining stable above $100 per barrel since 2012, leading their importance to attract interests from throughout the world again.

Figure 1 Real oil price and OECD economic growth



There are many uncertainties about the future course of oil prices. In the past, this *Outlook* projected specific oil price levels under the assumption that oil prices will follow an upward trend over a medium to long term. This is because global oil demand is expected to continue firm growth in the future. Higher-cost oilfield development will have to be implemented to make up for a decline in production from currently operating oilfields and secure new oil supply sources to satisfy the increasing demand. Specifically, if global oil demand increases at an annual average pace of 1 million barrels per day (Mb/d) in the future, the cumulative demand expansion through 2020 will be 5 Mb/d. At present, the international oil market has a supply surplus of a little more than 1 Mb/d. Given the abovementioned demand growth, however, some higher-cost oil production will be required due partly to a drop in production at currently operating oilfields, despite an expected increase in production in major Middle Eastern oil producing countries. Therefore, oil prices are expected to rise to $75/bbl or a higher level in 2020. In and after 2020, a continued expansion in demand and relevant investment (including investment in higher-cost oil production) could exert upward pressure on oil prices, leading oil prices to exceed $100/bbl in 2030.

However, current oil prices, from which the future prices are projected, have fallen to extremely low levels due to the plunge since the second half of 2014. Given progress in the shale revolution, potential growth in production in Iraq, Iran and other members of the Organization of the Petroleum Exporting Countries (OPEC) and energy conservation affecting oil demand growth, as well as the recent weakness of oil prices, we cannot necessarily conclude that oil prices could follow an upward trend as earlier expected. Therefore, we have analysed a *Lower Price Scenario* in which an oil price hike will be very limited. As indicated on Page 9 more specifically, the benchmark oil price will be limited to $70/bbl (or an even lower level) in 2020 due to a slack demand increase and a substantial expansion in unconventional crude oil production, and to $75/bbl in 2030 with a price hike remaining restricted. As the oil price plunge since the second half of 2014 and factors behind the plunge have led interests to globally grow in a future scenario that differs far from the traditional one, we must conduct an analysis responding to such growing interests.

Crude oil market history and latest price plunge, and oil pricing factors

The oil market history indicates that the latest oil price plunge has some similarities with the reverse oil crisis in the 1980s. First, an increase in production at new supply sources supported by earlier oil price spikes contributed to both oil price plunges. Second, both oil price plunges are not attributable to any economic shock for the demand side. Third, both oil price plunges came amid a production-expanding race between OPEC members (Table 1). Given the cyclic nature of the crude oil market, oil prices are expected to turn upward some time. However, the similarities between the latest plunge and that in the 1980s also indicate that the current oil price slump would not be short-lived.

Table 1 Differences between past oil price plunges

	1986	1998	2008	2014
Price plunge	-74%	-34%	-37%	-56%
Factors behind price plunge	• Oil demand fall under high prices following oil crises, expansion in non-OPEC oil supply • OPEC countries' market share-expanding race • Loose supply-demand balance caused by Saudi Arabia's netback pricing formula	• Decline in oil demand in emerging countries under Asian currency crisis • OPEC production exceeding quotas • Loose supply-demand balance caused by OPEC production quota expansion	• Global oil demand plunge under Lehman Shock • Production capacity expansion mainly by Saudi Arabia	• Non-OPEC supply expansion • Maintenance of OPEC production • Global demand decline • Production expansion by OPEC members (including Iraq, Saudi Arabia and Iran)

Note: Each price plunge indicates a change between the peak and bottom within six months on the New York Mercantile Exchange.

In the actual market (including futures markets), crude oil is priced based on expectations among market participants in regard to four factors – demand, supply, risks, and finance (Figure 2). This means that factors other than pure supply and demand factors can play roles in forming oil prices. Our estimation[1] indicates that historical oil prices were higher than indicated by supply and demand factors when oil prices were spiking from 2011 (Figure 3). Depending on international oil market developments in the future, factors other than those related to supply and demand could have great influences on prices again.

Figure 2 Factors contributing to forming oil prices

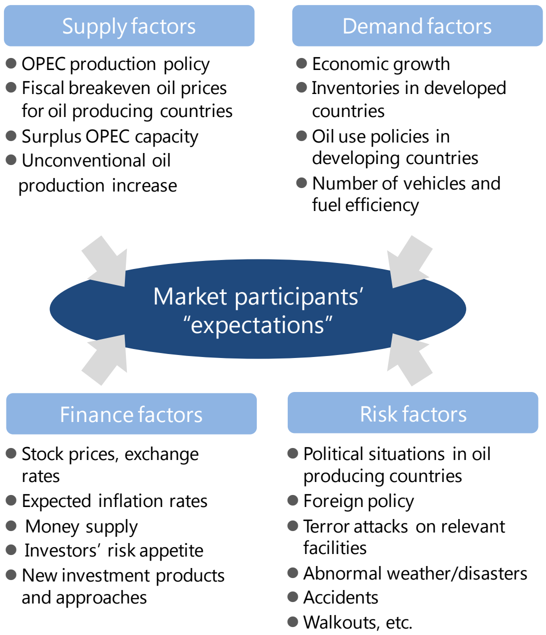
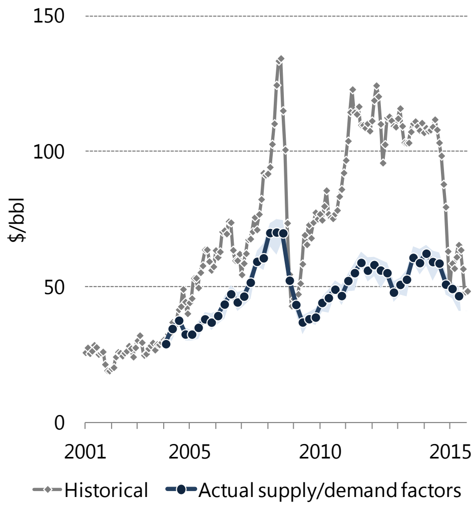


Figure 3 Historical oil price and actual supply/demand factors



Note: Front-month futures contract for Brent crude oil

Among non-supply/demand factors influencing future oil prices, geopolitical risks may exert influences that may not be negligible. Islamic State radical militants are operating mainly in Iraq and Syria. While Iran is steadily preparing for its comeback to the international oil market after the removal of economic sanctions, its neighbours are concerned about the Iranian move. In Ukraine, Russia has maintained a status quo change backed by its military power. There is the problem of security on the sea-lane between the Hormuz Strait and the Malacca Strait. We now see a great number of risk factors that may add premiums to oil prices irrespective of oil supply or demand. We must also take note of Russia's recent start of bombing in the Middle East and its impacts.

[1] Akira YANAGISAWA (2015) "Reconsidering oil price fundamentals – Non-supply/demand factors contributing greatly to oil price plunge," http://eneken.ieej.or.jp/report_detail.php?article_info__id=6284 [To be translated into English shortly.]

Asia/world energy supply and demand outlook

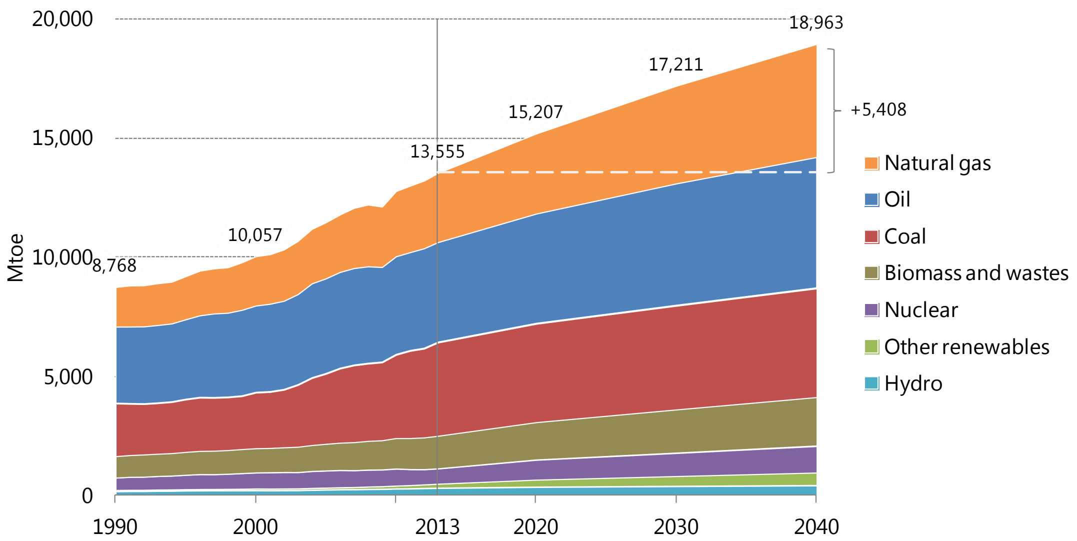
Energy consumption will expand 1.4-fold in 27 years. Fossil fuels will continue to account for most of energy consumption.

- Primary energy consumption in the world is decelerating its growth. In the *Reference Scenario* in which the current trends of social, economic, policy and technology changes regarding energy supply and demand are assumed to continue, however, global energy consumption will increase by 5,408 million tonnes of oil equivalent (Mtoe) from 13,555 Mtoe in 2013 to 18,963 Mtoe in 2040. The increase exceeds a combination of current consumption in China, the world's largest energy consumer, and the United States in the second position.

- Energy consumption will increase primarily in countries outside the Organisation for Economic Cooperation and Development (OECD). Non-OECD countries will expand energy consumption by 4,871 Mtoe by 2040, accounting for 90% of the global increase. Among them, China, India and the Association of Southeast Asian Nations (ASEAN) members will capture 55%. In contrast, OECD countries will command only 5% of the global energy consumption increase.

- At present, fossil fuels (oil, coal and natural gas) account for 81% of primary energy consumption. The situation will not change greatly as they cover 70% of new future energy demand. While hopes are placed on non-fossil fuels, even their combination is likely to fall short of rivalling any of the three fossil fuels.

Figure 4 Global primary energy consumption



- Oil consumption, which stood at 87.1 Mb/d in 2013, will increase to more than 100 Mb/d in the mid-2020s and reach 113.7 Mb/d in 2040, driven by demand growth in the transport sector including automobiles. The increase of 26.6 Mb/d from 2013 to 2040 exceeds the present crude oil production in Middle Eastern and North African OPEC members at 25.2 Mb/d. Even in 2040, oil remains the largest energy source.

▌ The oil supply-demand balance is loose due to growing unconventional oil production in the United States, OPEC's strategy of giving priority to market shares and emerging economies' slackness. After a substantial United States production expansion lasting until around 2020, however, the world will grow more dependent on a production increase in traditional oil-producing countries including those in the Middle East. Given considerable time and investment required for oil resources development and many oil-producing countries' restrictions on foreign investment, it is not easy to expand new supply capacity flexibly. How the present low oil prices would affect supply expansion investment would have to be checked prudently, with strategic responses being considered.

Figure 5 Oil consumption changes

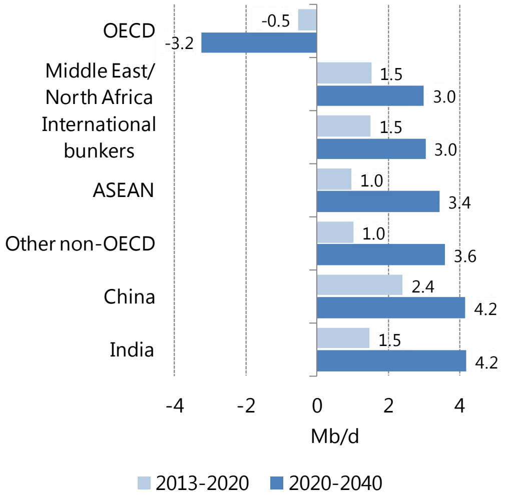
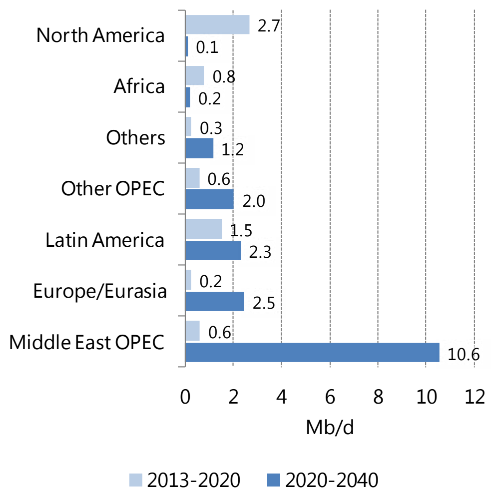


Figure 6 Crude oil supply changes



▌ Natural gas will post a faster consumption increase than any other energy source, replacing coal as the second largest energy source after oil by 2040. Although the final consumption sector (covering buildings, industry, non-energy use and transport) accounted for more than half of natural gas consumption until 2006, the power generation sector and the final consumption sector each will capture a little more than 40% of an increase of 2.23 trillion cubic metres (TCM) in natural gas consumption to 5.75 Tcm in 2040.

▌ Liquefied natural gas (LNG) demand will more than double from 239 million tonnes (Mt: 0.33 Tcm) in 2014 to 547 Mt (0.74 Tcm), accounting for 46% (compared with 33% in 2014) of natural gas trade between major regions. Natural gas trade will be further diversified as production and consumption areas increase against the backdrop of growing consumption of unconventional gas resources. LNG will play a key role in supporting the diversification.

▌ Coal consumption will decelerate growth in the future, after expanding to cover 45% of global energy consumption growth since the beginning of this century. While coal consumption is expected to increase by 17% to 6,539 million tonnes of coal equivalent

(Mtce)[2] in 2040, the growth rate is the lowest among energy sources. The great change is attributable to Chinese developments, including slowing economic growth and an emerging shift to a cleaner energy mix, and their effects. In the second half of the *Outlook* period, India's influence on global coal consumption will remarkably grow stronger. Steam coal for power generation will account for most of global coal consumption growth. While Europe and the United States with relatively easier access to cheap natural gas are switching from coal to natural gas, cleaner use of coal has great significance in Asia.

- Coal trade will increase, centring on steam coal trade in the Asian market where coal demand will increase. In place of China that has rapidly expanded coal imports, India and ASEAN will increase their coal imports. Among coal-exporting countries, Indonesia will reduce exports due to growing domestic demand and its coal resources protection policy, after the past fast increase in steam coal exports. Coal importers will thus grow more dependent on Australia.

Figure 7 Natural gas consumption

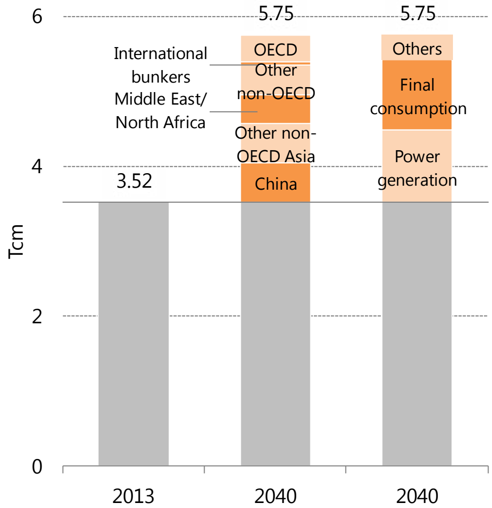


Figure 8 Coal consumption changes

Note: Annual average change in each period

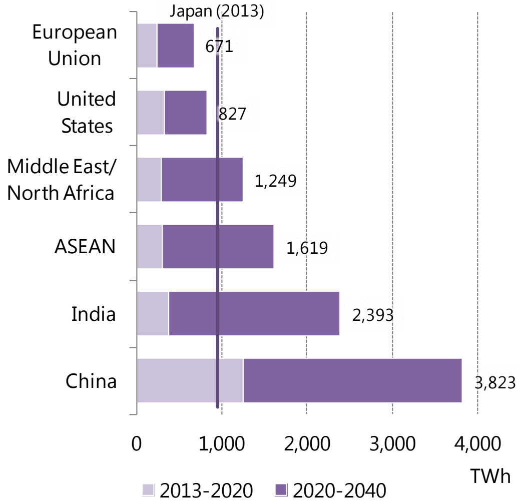
- Final electricity consumption has continued increasing in the past, excluding 2009 when consumption fell on the global financial crisis, and will continuously expand in each region irrespective of economic development stages or geographical conditions. Particularly, non-OECD will post remarkable growth in electricity consumption after surpassing OECD in 2012. Electricity consumption growth in China will be equivalent to four times Japan's present consumption. Indian growth will be equivalent to 2.5 times.

- Power generation will remain heavily dependent on fossil fuels (accounting for nearly 70% of total generation). However, coal-fired power generation will reduce its share by 7 percentage points to 35% due to a drop in Europe and the United States. Instead,

[2] 1 Mtce = 0.7 Mtoe.

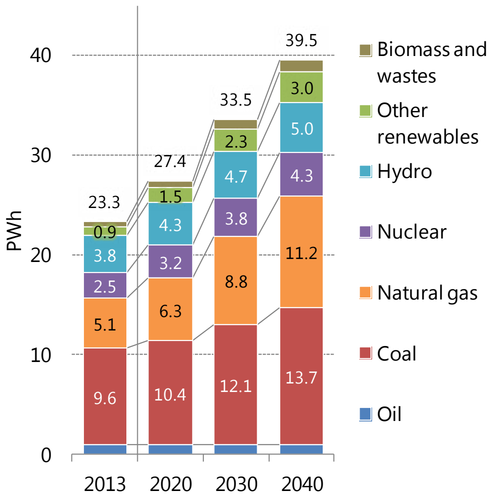
natural gas-fired power generation will increase its share by 7% points to 28%. Nuclear and renewable energy will retain their respective present shares of power generation.

Figure 9 Increases in final electricity consumption in selected regions



Note: The vertical line indicates Japan's consumption at 950 TWh in 2013.

Figure 10 Global power generation mix



- Renewable energy's share of power generation will stand at 23% in 2040, changing little from 22% at present. However, wind and solar photovoltaics power generation will expand fast from 789 terawatt hours (TWh) in 2013 to 2,778 TWh in 2040 due to policy support and technological development, accounting for 7% of total power generation. Power generation capacity will grow 3.1-fold to 998 gigawatts (GW) for wind power and 5.5-fold to 749 GW for solar PV. Hydropower generation will increase slowly, while its share will decline with large-scale development decelerating.

- Nuclear power generation will increase from 2,478 TWh in 2013 to 4,321 TWh in 2040, though with its share of total power generation remaining almost unchanged from 11% at present, as is the case with renewable energy. Nuclear power generation capacity will decline in seven countries and regions, including Germany that plans to terminate nuclear power generation in the 2020s and Japan that is expected to cut capacity by 23 GW by 2040. In contrast, 32 countries will expand nuclear power generation capacity, including 13 planning to introduce nuclear power generation. Global nuclear power generation capacity will expand form 389 GW in 2013 to 610 GW in 2040.

Towards energy conservation and decarbonisation

There is no royal road to energy conservation, but there are orthodox means.

- Five energy conservation principles: (1) understanding the significance of energy conservation, (2) checking energy consumption, (3) taking action for energy conservation, (4) improving equipment efficiency, and (5) promoting innovation with latest technologies such as Internet of Things. Appropriate use or operation of equipment (reducing wasteful use) and maintenance for keeping performance play a key role in energy conservation.

Energy conservation generates benefits while resulting in commensurate costs in most cases. For example, the introduction of highly efficient lighting may generate cumulative benefits worth $1.4 trillion due mainly to a decline in fuel consumption for power generation and result in an additional cost of $400 billion through 2040, bringing about net benefits worth $1 trillion.

Figure 11 Five energy conservation principles

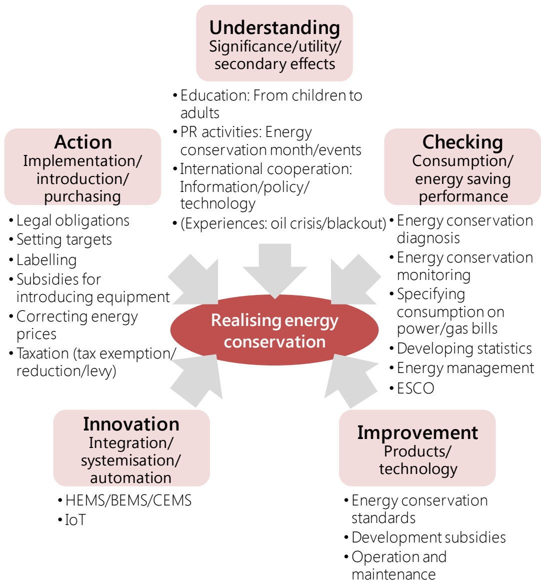
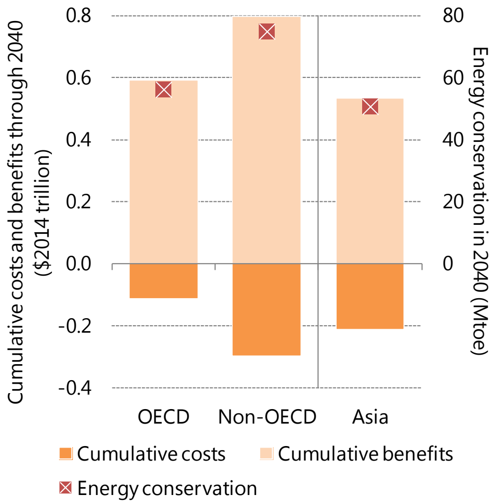


Figure 12 Costs and benefits of highly efficient lighting and energy conservation



In the *Advanced Technologies Scenario* that assumes maximum carbon dioxide emission reduction measures based on their application opportunities and social acceptability, energy consumption in 2040 will be 2,567 Mtoe less than in the *Reference Scenario*, with the increase from the present level limited to 53% of the growth in the *Reference Scenario*. Asia including China and India will account for 45% of the energy savings, playing a key role in energy conservation. Particularly, Asia will capture as much as 74% of coal consumption savings. Asia will also command 56% of an increase in consumption of nuclear and non-hydro renewables including solar PV and wind.

Among energy sources, coal mainly for power generation will post the largest consumption decline from the *Reference Scenario* due to an electricity demand fall, power generation efficiency improvement and switching to other energy sources. Total fossil fuel will be 3,387 Mtoe less than in the *Reference Scenario*, while nuclear will be 471 Mtoe more and renewables 350 Mtoe more. As a result, fossil fuels' share of power generation will drop from 81% in 2013 to 70% in 2040.

Figure 13 Primary energy consumption

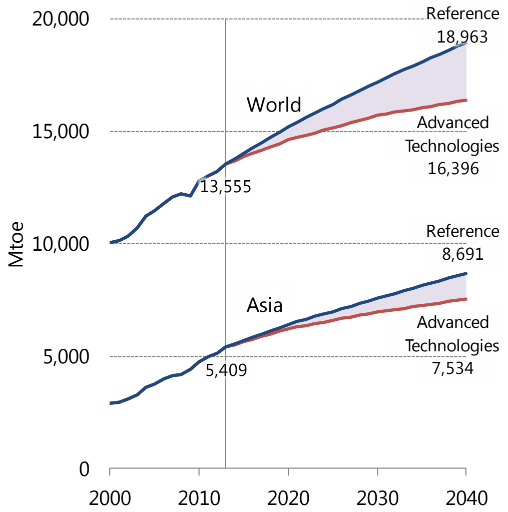
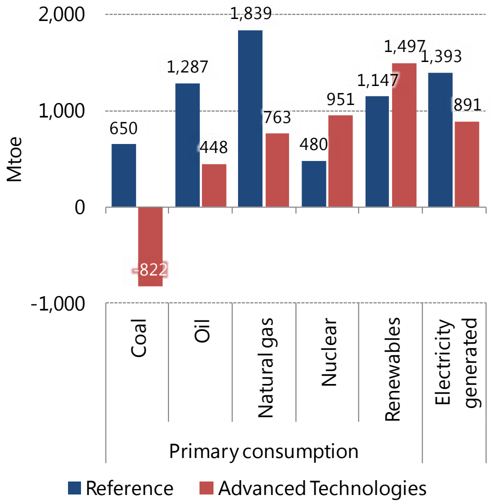


Figure 14 Energy consumption changes [2013-2040]



Results from lower energy prices

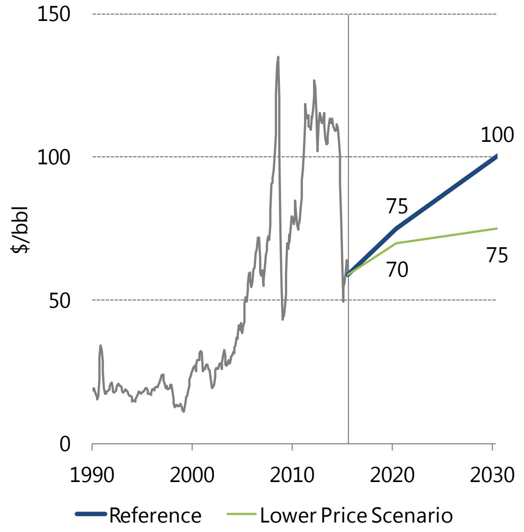
Lower prices resulting from consumption reduction and resources development will change the world.

- In the *Lower Price Scenario*, we assumed that fossil fuel demand will be held down through policies for energy security, climate change mitigation and other purposes. The energy supply-demand balance will also ease as energy supply capacity expands substantially due to global progress in the development of unconventional oil and natural gas resources through technology advancement. The oil price in 2030 is assumed at $75/bbl in the *Lower Price Scenario* against $100/bbl in the *Reference Scenario*.
- In the *Lower Price Scenario*, the effects of energy conservation measures, assumed to be strongly promoted, will far exceed those of global economic expansion (described later) and rebound caused by lower energy prices. Required energy supply in 2030 will total 16,048 Mtoe, as much as 1,163 Mtoe less than in the *Reference Scenario*. Oil supply in 2030 will total 96.5 Mb/d with the increase from the present level limited to 7.7 Mb/d due to switching from oil to other energy sources. As unconventional oil production expands substantially mainly in North America, the increase in Middle Eastern oil production will be limited to 1.0 Mb/d, with Russia forced to reduce oil production by 0.8 Mb/d.
- Natural gas production will be affected by energy conservation, while switching to natural gas from other energy sources will make progress. This will not be the same case with oil. Natural gas production in 2030 in the *Lower Price Scenario* will increase by 825 Bcm from the present level to 4,355 Bcm, slipping below 4,971 Bcm in the *Reference Scenario*. Production will decline substantially in North America, the former Soviet Union, the Middle East and other net exporters, all affected by demand restrictions in other regions.

Table 2 Background for oil price assumptions

	Reference	Lower Price
Demand	The current trend of progress in energy conservation and fuel switching in the transport sector will continue	Progress in energy conservation Progress in switching to non-fossil fuels
Supply	Conventional resources The same progress as in the past in each country Unconventional resources United States production expansion pace will slow down in and after the 2020s Gradual progress in other countries	Conventional resources OPEC, Russia and other oil producers will continue a production expanding race OPEC will effectively collapse as a cartel Unconventional resources Increasing to peaks in the United States and other countries

Figure 15 Oil price assumptions



Note: Future prices are in 2014 prices.

Figure 16 Crude oil production in selected regions [2030]

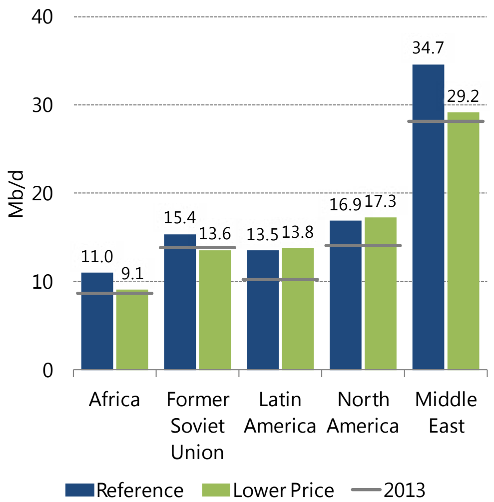
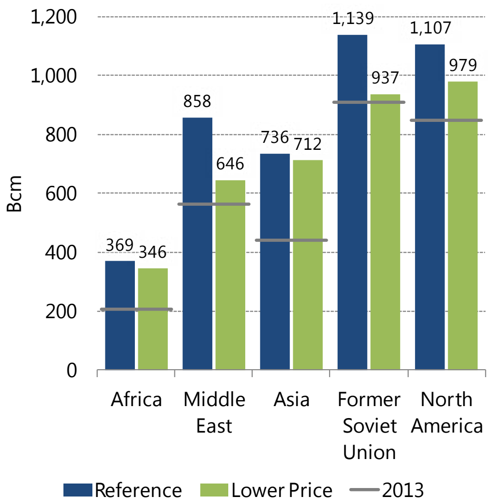


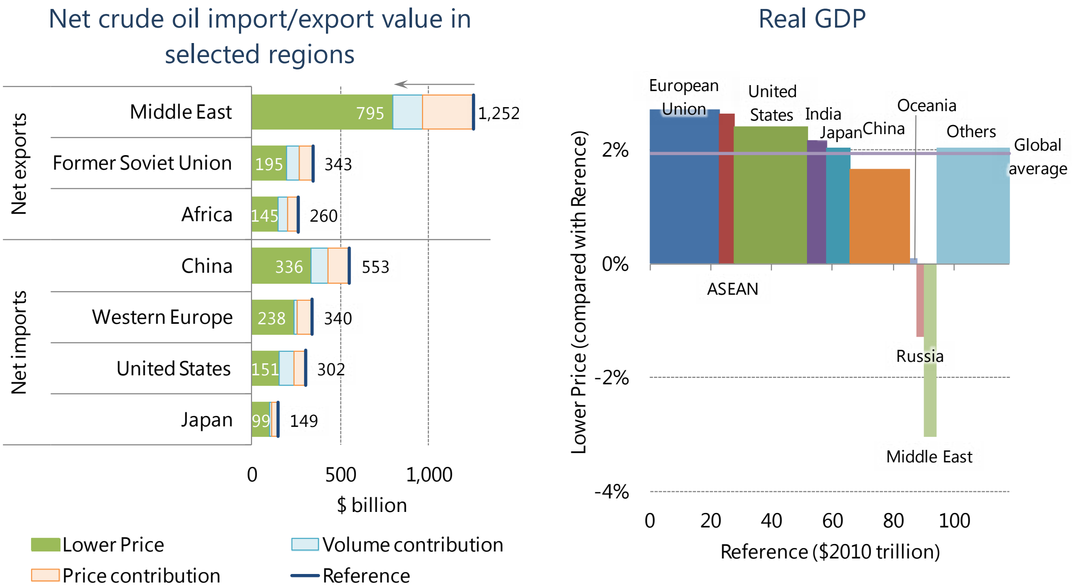
Figure 17 Natural gas production in selected regions [2030]



An oil price fall will directly invigorate net oil-importing economies over a short term by helping reduce their income outflow and raise their real purchasing power. The benchmark oil price in August 2015 dropped by $55/bbl year on year. If the drop is maintained, net oil importers' payments will be cut by $860 billion annually, with their economies growing by 1.5%. On the other hand, such oil price drop will work to shrink net oil-exporting economies by 3.7%. Nevertheless, the oil price fall will serve to expand the world economy by 0.7%.

In the *Lower Price Scenario* in which oil demand will be restricted with oil prices falling, net crude oil imports and exports in value[3] will shrink substantially (Figure 18). Net imports of other fossil fuels will also be restricted, benefiting energy-importing economies. The entire world economy will expand by 1.9%. In Middle Eastern and other countries that depend heavily on revenues from energy exports, however, the energy exports decline will exert downward pressures on economies.

Figure 18 Impacts of loose energy supply-demand balance and low prices [2030]



Note: Combined effects of energy price drops, fossil fuel savings and use of unconventional oil and natural gas resources

Excessively volatile energy prices could affect appropriate investment on both the supply and demand sides, destabilising the future supply-demand balance. Promoting constructive discussions between energy producing and consuming countries to share market outlooks and other information and understanding for sound market development for various energy sources like oil, natural gas and LNG will be significant for stabilising energy markets and triggering their sustainable development. To this end, the International Energy Agency (IEA) and OPEC should promote their talks through the International Energy Forum and other forums. To secure communications between energy consuming countries, the IEA should enhance cooperation with China and India that will expand oil imports in the future.

[3] Nominal value

Realistic approach required on climate change issue

INDC implementation alone may fail to reduce GHG emissions substantially.

- Global energy-related CO_2 emissions will increase by 39% from 2013 to 45.9 Gt in 2050 in the *Reference Scenario*. In the *Advanced Technologies Scenario* accompanied by carbon capture and storage (CCS), CO_2 emissions will be reduced by 29% from the present level to 23.3 Gt. However, the emissions will still fall short of being halved.

- Based on intended national determined contributions (INDCs) commitments by seven major countries and the European Union[4], global GHG emissions in 2030 are estimated at a level that is closer to the *Reference Scenario* than to the *Advanced Technologies Scenario*. The United States and Japanese estimates are close to those in the *Advanced Technologies Scenario* and the European Union estimate is midway between the estimates in the *Advanced Technologies* and *Reference Scenarios*. The Chinese estimate is close to the *Reference Scenario* level, while the Indian estimate exceeds the *Reference Scenario* level. All parties will be required to make efforts in line with the *Advanced Technologies Scenario*. Particularly, developing countries will have to effectively enhance their GHG emission reduction efforts.

Figure 19 Global CO_2 emissions and each measure's contribution to emission reductions

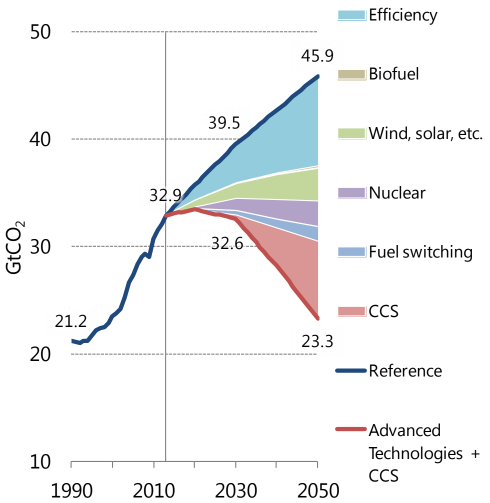
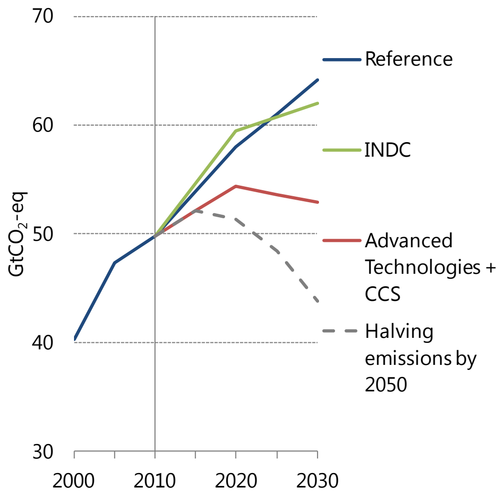


Figure 20 GHG emissions



Note: GHG emissions for the Reference Scenario and the Advanced Technologies Scenario plus CCS are assumed proportional to the energy-related CO_2 emissions.

[4] The seven major countries and the European Union accounted for 65% of global GHG emissions in 2010.

Take advantage of time left to spare for making balanced efforts with future technologies and adaptation taken into account.

- In the extension of the *Reference Scenario*, the atmospheric concentration of GHGs in 2100 will come to 760-860 ppm (parts-per-million CO_2-equivalent) with the average temperature change from the 1850-1900 period reaching 2.8-4.0°C. In the extension of the *Advanced Technologies Scenario* accompanied by CCS, the GHG concentration in 2100 will total 540-600 ppm, with the temperature change reaching 1.7-2.4°C. The temperature will thus slip below 2.5°C and could fall below 2°C, indicating that the scenario could be combined with adaptation measures[5] into an option close to the one that would halve CO_2 emissions in 2050 from 2013 and eliminate them in 2100.

- If CO_2 emission reduction and other climate change mitigation measures[6] are implemented in the *Reference Scenario*, mitigation costs will increase with "adaptation and damage" costs decreasing. Adaptation and damage costs will be less than mitigation costs over a short to medium term. Over a long term beyond 2050, however, they will grow larger. While uncertainties are still great regarding these cost estimates, there may be some point at which a total of mitigation, adaptation and damage costs could be minimised between the *Reference Scenario* and the scenario for halving GHG emissions by 2050. Mitigation, adaptation and damage costs trade off with each other, meaning that it is impossible to reduce the three simultaneously. A realistic option may be to balance the three with minimisation of the comprehensive costs kept in mind.

[5] Adaptation measures are designed to prevent adverse effects of climate change, including damage from sea level rise, farm drought and new disease epidemics. These measures include river and coastal banks, storage reservoirs, agricultural research, and disease prevention and treatment.

[6] Mitigation measures are designed to artificially reduce GHG sources or expand GHG sinks to hold down greenhouse effects.

Figure 21 Temperature rise from 1850-1900

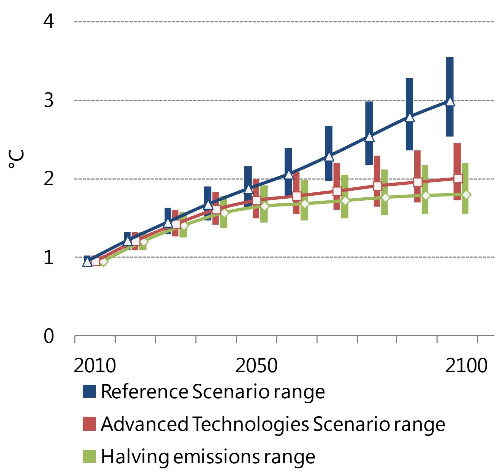
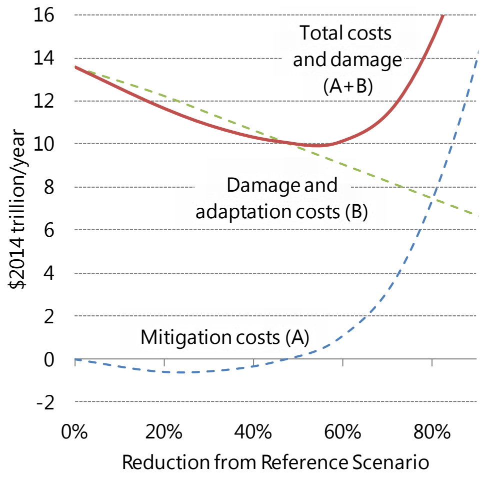


Figure 22 Mitigation and adaptation costs and damage [2100]



Note: Mitigation costs were estimated by the IEEJ. Damage and adaptation costs are based on the formula under the DICE2013R model[7]. The equilibrium climate sensitivity is assumed at 3°C.

Given climate change effects, it goes without saying that very ambitious GHG reductions will be required over a long term. For the immediate future, the world should seek to lower the GHG concentration by adopting the target of the 500-550 ppm category close to the *Advanced Technologies Scenario* and developing low-cost technologies for such purposes as energy conservation, CO_2 reduction and absorption. Over a medium to long term, the world should proactively develop innovative technologies, including carbon capture and use (CCU) – particularly, artificial photosynthesis –, next-generation nuclear power, space-based solar power and nuclear fusion, and should adopt a cooperative approach to build worldwide networks linking national technology development efforts.

[7] W. Nordhaus and P. Sztorc (2013), "DICE 2013R: Introduction and User's Manual". http://www.econ.yale.edu/~nordhaus/homepage/documents/DICE_Manual_103113r2.pdf

Part I

Volatile energy prices and implications for future outlooks

1. Analysing crude oil and natural gas prices

1.1 Crude oil prices

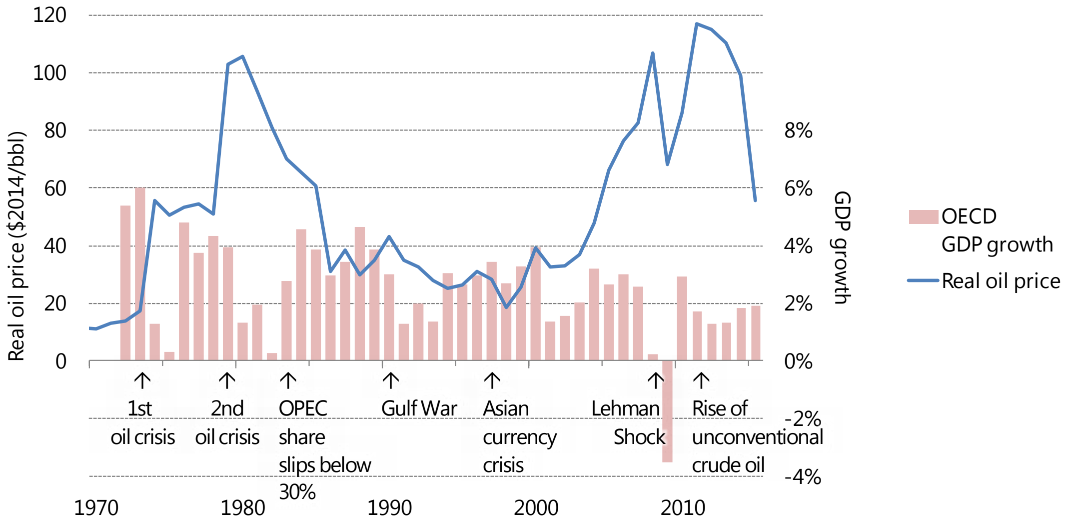
Why reviewing crude oil prices?

This Outlook focuses on crude oil prices and analyses scenarios for different price levels. There are fundamental and contemporary reasons for taking up crude oil prices anew.

Importance of crude oil prices for world economy

First, it may be needless to say that fundamentaly crude oil prices exert great influences on the world's politics and economy. Crude oil is the world's largest trading commodity. As crude oil producing regions collect massive rent (excessive profit), trade in the commodity causes huge wealth transfers that greatly influence the balance of power in international politics. In terms of energy supply and demand, oil is the world's largest primary energy source[8], being used for transportation, power generation and petrochemicals and consumed in the industry, commercial and residential sectors. Therefore, crude oil prices are one of the important input prices for the macro economy and influence economic activities overall (Figure 23). In Asia and some other regions, crude oil prices are also used for pricing natural gas, serving as a key benchmark for the selection of energy sources. In considering future energy problems, therefore, crude oil prices are one of the most important factors.

Figure 23 Real oil price and OECD economic growth



[8] According to the BP Statistical Review of World Energy 2015, oil accounted for 33% of total energy demand in 2014.

Increased importance of crude oil prices

One of the contemporary reasons for taking up a review of crude oil prices is that they plunged rapidly during the second half of 2014 and remained weak ever since. The Brent crude oil price stood around $110/bbl in July 2014 and started a rapid drop in the autumn of that year. As of late September 2015, the price stood around $40/bbl. It is the understanding of the impacts of such price plunge on future global energy supply and demand that motivates this analysis.

Another contemporary reason is that the crude oil price weakness is expected to remain over the long term rather than ending in one year or two, as a short-term phenomenon. The history of the crude oil market includes cases of such rapid oil price plunges (Table 3). The latest is similar to the sharp drop in the 1980s as they both resulted from an increase in non-OPEC oil supply under prolonged high price levels rather than any demand-side shock like an economic crisis. As a matter of course, the present international crude oil market differs from that in the 1980s as the price elasticity of oil demand has declined due to the diversification of market players and the transport sector's growing share of oil demand. Moreover, shale oil's growing price competitiveness (productivity improvements, lower prices for materials and equipment), expected growth in supply from Iraq and Iran, and the reluctance by Saudi Arabia to revise its present production policy have increased the chance for oil prices to remain weak over the long term, as seen in the 1980s and after.

Table 3 Differences between past oil price plunges

	1986	1998	2008	2014
Price plunge	-74%	-34%	-37%	-56%
Factors behind price plunge	• Oil demand fall under high prices following oil crises, expansion in non-OPEC oil supply • OPEC countries' market share-expanding race • Loose supply-demand balance caused by Saudi Arabia's netback pricing formula	• Decline in oil demand in emerging countries under Asian currency crisis • OPEC production exceeding quotas • Loose supply-demand balance caused by OPEC production quota expansion	• Global oil demand plunge under Lehman Shock • Production capacity expansion mainly by Saudi Arabia	• Non-OPEC supply expansion • Maintenance of OPEC production • Global demand decline • Production expansion by OPEC members (including Iraq, Saudi Arabia and Iran)

Note: Each price plunge indicates a change between the peak and bottom within six months on the New York Mercantile Exchange.

If the oil price weakness remains over the long term, it will surely exert great impacts on future energy supply and demand. Low oil prices' stimulation of oil demand and constraints on upstream oil resources development could cause the oil supply-demand balance to rapidly tighten, as seen after the middle of the 2000s. The crude oil price plunge and subsequent natural gas price drops could also change the price relationship between fuels and affect fuel choices. Furthermore, the oil price plunge will affect the diffusion of renewable energy and the promotion of low-carbon policies. If resource-rich countries' fiscal conditions deteriorate due to the prolonged crude oil price weakness, it may affect overall political and economic conditions. Given these possibilities, it is very significant to conduct analyses based on plural crude oil price scenarios for projecting into the future.

Factors influencing crude oil prices

What factors are contributing to forming crude oil prices? We here briefly explain the factors influencing oil prices as they are related to later scenario discussions. They are divided into three categories -- supply and demand factors, risk factors, and financial and speculative factors.

Demand factors

It may be needless to say that the oil supply and demand trends are among the most important factors forming crude oil prices. While oil demand has entered a structural downward trend in advanced countries due to improvements in vehicle fuel efficiency and falling population, demand is expected to increase in emerging countries thanks to expanding economic activities, income growth and progress in motorization.

Oil is used not only in the transport sector but also in other sectors including buildings, power generation, industry and petrochemicals. In the future, oil demand will increase mainly for transport and petrochemicals while, epoch-making technological progress in electric or natural gas vehicles and alternative fuels such as biofuels and hydrogen may largely decelerate the growth.

Supply factors

The supply trend is as important as the demand trend. In the absence of economic shocks, oil demand tends to increase at a certain annual pace while supply can change greatly and rapidly depending on crude oil price levels, OPEC production policies and other factors. Therefore, supply factors have more often decisive effects on daily crude oil prices than demand factors and holding the decisive key to future oil supply may be the fate of the ongoing U.S. shale revolution. The global oil supply picture could change greatly depending on how far continuing productivity improvements and cost cuts for shale oil production would go and on how far shale oil production technologies would diffuse outside North America. Attracting attention as a future conventional oil supply source is an increase in oil output in non-Gulf Middle Eastern countries Iran and Iraq. In Iraq, oilfields that have been developed after the Iraq war are smoothly expanding output. As transport and shipment infrastructure problems (current bottlenecks) are solved, Iraq may increase output further. As in Iraq, Iran may expand its oil production capacity and output using foreign capital if Western countries lift their economic sanctions smoothly.

Risk factors

Non-supply/demand factors such as sudden or unexpected events that actually affect supply and demand and are identified by market participants as such are generally called risk factors. These risk factors exert great influences on crude oil prices. Representative risk factors include political destabilization in oil producing regions (the so-called geopolitical risk), natural disasters such as hurricanes and earthquakes, and accidents at oil production facilities. Most risk factors serve as sudden factors with less long-term influences on oil prices than supply or demand factors. Among risk factors, however, structural political turmoil in the Middle East is a factor that could exert great influences on future crude oil prices. Prolonged political instability in Iraq and Syria, particularly radical Islamic State (IS) militants' expanding operations since the spring of 2014, could destabilize the political situation not only in Iraq and Syria but also in the whole of the Middle East and North Africa through terrorism and armed attacks. In fact, militants claiming to be IS members conducted terrorist attacks against Shiite Muslims in eastern Saudi Arabia in April 2015. There is a risk that the IS and IS-influenced organizations could cause events affecting oil supply in the Middle East and North Africa.

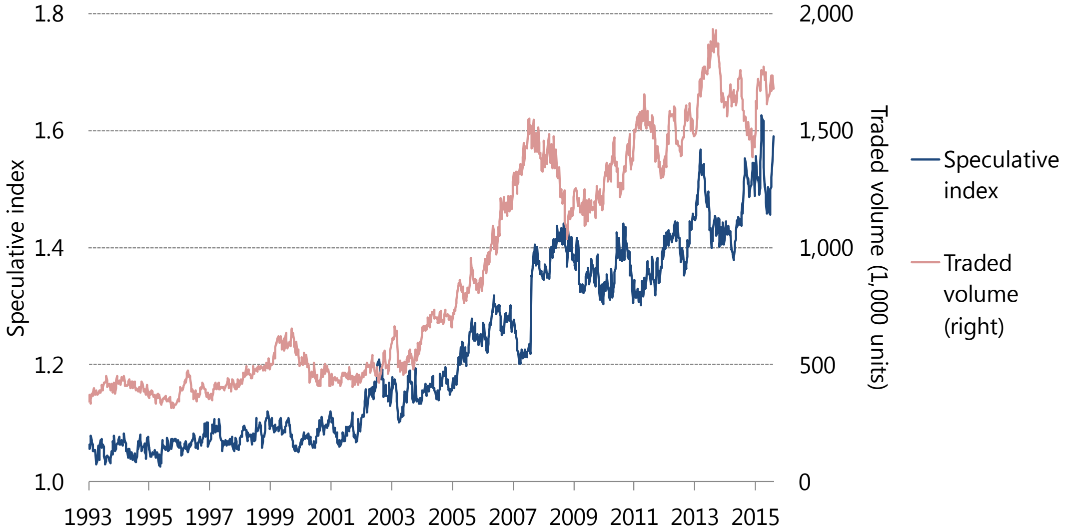
At a time when Western countries are moving to lift economic sanctions on Iran, we cannot ignore the fact that Iran's neighbours are concerned about Iran's rising as a regional power again. While any large-scale dispute involving the whole of the Middle East is unlikely to occur, limited disputes such as the Yemen situation are likely to emerge at any time, leading crude oil prices to rise.

Russia's aerial bombing on Syria, which started in September 2015, could also create more destabilizing factors by shaking the regional political power balance. Even outside the Middle East, Russia has changed the status quo by the use of force in Ukraine. In Asia as well, some events could affect crude oil prices. If security in sea lanes from the Strait of Hormuz to the Strait of Malacca and Singapore is threatened, it may exert a great impact on the crude oil market.

Financial and speculative factors

In addition to the three abovementioned categories of factors, financial and speculative factors have been growing more important over recent years. Since the mid-2000s when commodity futures as a whole became alternative investment targets, massive investment money has been flowing into the crude oil futures market. On the New York Mercantile Exchange (NYMEX), as a result, open interest for crude futures quadrupled for 300,000-400,000 contracts in the beginning of the 2000s to 1.6 million contracts in September 2015. Working's speculative index, which measures excessive speculation, rose from 1.1-1.2 in the beginning of the 2000s to 1.5-1.6 in September 2015. These changes indicate that investment money's flow into the crude oil futures market is no longer any temporary phenomenon and that crude oil futures are viewed as one of the leading investment "commodities" in the world's financial markets.

Figure 24 Traded volume and speculative index in NYMEX



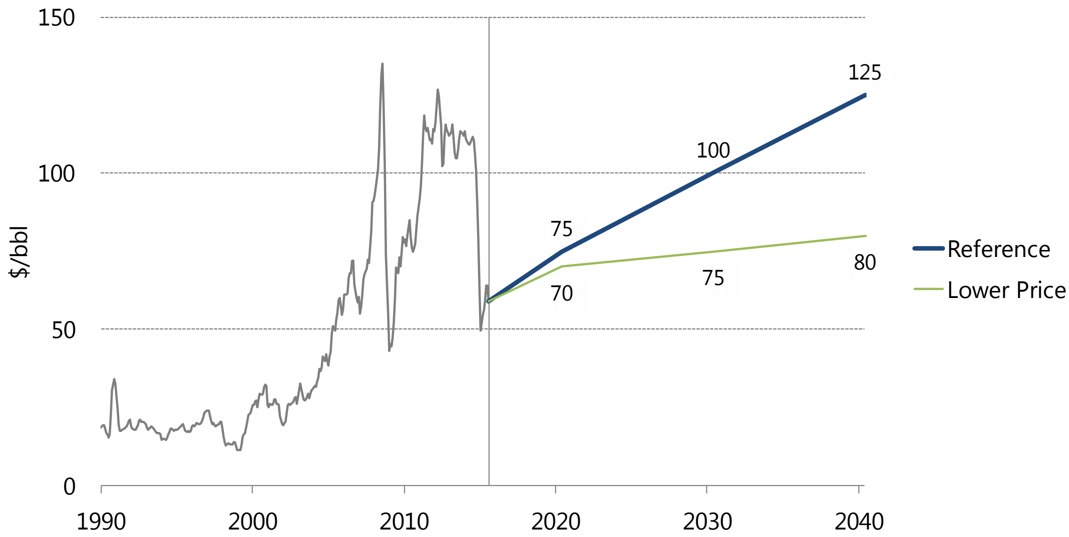
Investment money moves in the world's financial markets are susceptible to government and central bank monetary policies. Monetary easing may encourage investment money to flow into the crude oil futures market by increasing investors' risk appetite. Conversely, monetary tightening may lead money to leave the risky commodity futures market. While the United States is discussing an interest rate hike toward the end of 2015, Europe and Japan are likely to maintain their accommodative monetary policy. Investment money moves and crude oil price changes are thus expected to continuously have strong correlations.

Meanwhile, Western countries have been moving to toughen regulations on excessive speculative transactions on the commodity futures market. This is because daily crude oil prices have become susceptible to stock prices, exchange rates and other financial and economic indicators having no relations with oil supply or demand and to geopolitical risks, and have deviated from actual supply and demand fundamentals as crude oil futures have become a financial instrument. Moves to toughen such regulations might have lost some momentum as crude oil prices have plunged since the second half of 2014. But appropriate regulation frameworks should be developed promptly to prevent excessive speculative transactions that could destabilize the crude oil market.

Price assumptions

Crude oil price assumptions for the *Reference* and *Lower Price Scenarios* are given in Figure 25. The price trend in the *Reference Scenario* is viewed as the most feasible one based on forecasts for the above three categories of factors influencing oil prices. The *Lower Price Scenario* is less likely than the *Reference Scenario* but could be realized if various factors work in a composite manner.

Figure 25 Crude oil prices assumptions



Note: Future prices are in 2014 prices.

Background for Reference Scenario

On the demand side, motorization will make smooth progress in line with income improvements in emerging countries, including China, as their economies grow robustly. Oil demand will therefore continue increasing as the auto fleet will also expand due to population growth. Despite vehicle fuel efficiency that will continue to improve gradually, oil's superiority in the transport sector will still remain unshaken even by 2040. Electric, fuel cell and natural gas vehicles will not diffuse in a full-blown manner by then.

On the supply side, U.S. shale oil production will peak in the 2020s while development will continue in major production areas such as Bakken, Eagle Ford and Permian. Global shale oil output will continue increasing until 2040 as non-U.S. shale oil development makes steady progress toward 2030 despite a number of geological, technological and political constraints or problems. Conventional oil output in Iraq, though failing to reach the government target of 9 million barrels per day (Mb/d) in 2020 due to political deterioration, will reach 6 Mb/d in 2030. Iranian oil production capacity will reach 6 Mb/d by 2040, as foreign companies take part in oil development following the termination of Western economic sanctions.

As the oil supply-demand balance tightens gradually after the current oversupply, sporadic risk factors will exert upward pressure on crude oil prices. While fundamental solutions will fail to resolve disputes in the Middle East including Syria and Iraq, the IS and IS-influenced radical groups will continue armed attacks in the Middle East and North Africa. As Western countries will lift the economic sanctions on Iran, imposed over its nuclear development program, Iran's comeback to the international community and confrontation with its neighbours will remain deep-rooted and serve as a destabilizing factor in the Middle Eastern situation. The Russian military operations launched in Syria in 2015 further deteriorated the existing Russia-U.S. confrontation over the Ukraine problem. If Western economic sanctions on Russia continue, Russian oil output will fall short of increasing greatly with Western companies failing to promote investment in Russia.

Meanwhile, financial and speculative factors will continue to shake crude oil prices on a daily basis. Given that a number of countries are expected to retain monetary easing policy until around 2020, crude oil prices and financial indicators are likely to continue to have strong correlations. Attempts to regulate speculative transactions in Western countries since the late 2000s will gradually work to restrict excessive speculation, while failing to decisively stop investment money's flow into the crude oil futures market. So, crude oil futures will remain one of the investment targets.

In the *Reference Scenario,* the benchmark crude oil price is assumed at $75/bbl for 2020 and more than $100/bbl for 2030. If global oil demand increases by an annual average of 1 Mb/d, the cumulative increase through 2020 will total 5 Mb/d. The current supply surplus of more than 1 Mb/d in the international oil market and the potential output increase in major Middle Eastern oil producing countries are not sufficient and some high-cost oil production will be required to meet the abovementioned demand expansion. Therefore, the crude oil price is assumed to rise to $75/bbl or more by 2020. From 2020, continuous demand growth and investment in expanding supply (including high-cost oil) will exert upward pressure on the crude oil price. So, the price is assumed to rise further by 2030.

Background for Lower Price Scenario

On the demand side for the *Lower Price Scenario*, motorization itself will make progress as in the *Reference Scenario*. But auto fuel efficiency regulations will diffuse as a part of energy conservation measures not only in advanced countries but also in developing nations based on Western experiences. Global auto fuel efficiency will continue to improve while the selling price for hybrid and other next-generation vehicles will fall. Through 2040, oil demand growth in the transport sector will be restricted due to technological breakthroughs regarding battery costs and capabilities for electric, natural gas and fuel cell vehicles.

On the supply side, despite low oil prices, U.S. shale oil output will reach 5.5 Mb/d in 2020 as productivity improves. Later, the production growth will decelerate due to domestic geological constraints. In the meantime, shale oil development will spread in Argentina, Mexico, Turkey, China and other countries, leading global shale oil output to rise to 8.9 Mb/d in 2030. Within OPEC, Saudi Arabia and other Persian Gulf oil producing countries will escalate the rivalry that began in the mid-2010s with Iran and Iraq and, therefore, OPEC will no longer work effectively as a cartel. From 2020 through 2030, OPEC's influence on the crude oil market will remain limited and Iran will expand oil output. Later, upstream oil development investment will expand in African oil producing countries, increasing global supply.

As the supply-demand balance stays structurally loose, risk factors will have less chance to be reflected in the crude oil market. The Middle Eastern situation, including Syrian and Iraqi conditions, and the Russia-Ukraine situation, though remaining unstable, will be stalled and avoid decisive deterioration, limiting the possibility of working to exert upward pressure on crude oil prices.

In the meantime, Western countries' enhanced regulations on speculative transactions will gradually succeed in reducing excessive speculation in the finance and investment area. At the same time, a decline in crude oil price volatility under the loosening supply-demand balance will help prevent speculative money from flowing into the crude oil market. Influences of financial and speculative factors on the crude oil market will thus decrease gradually.

In the *Lower Price Scenario*, the benchmark crude oil price will stand at $70/bbl (or less) in 2020 and will still be limited to $75/bbl in 2030. The price is assumed to turn upward from the present low level (in October 2015) due to the low price's stimulation of demand and restrictions on output at high-cost wells mainly in non-OPEC oil producing countries over a short-term, rallying to around $70/bbl in 2020. Later, however, substantial growth in unconventional oil output and restrictions on demand growth are assumed to cap a price hike, limiting the price in 2030 to $75/bbl.

1.2 Natural gas prices

Natural gas as a commodity

The combustion of natural gas, consisting primarily of methane (CH_4), emits less carbon dioxide (CO_2) and sulphur oxide (SO_x) than oil or coal, having an environmental advantage. But the calorific value per volume of natural gas is limited to only one-1,000th of that of oil and the calorific value per volume of liquefied natural gas is about one-1.7th that of oil.

The liquefaction of natural gas to reduce the volume to one-600th of the volume of the gas in its natural state has allowed natural gas to be transported by sea over long distances. But high-cost nickel and stainless steel and aluminium alloy are used for LNG tanks to keep the temperature as low as minus 162 degrees Celsius. Such characteristics of LNG require massive investment in the LNG distribution process including liquefaction plants, tankers and receiving terminals.

Therefore, the efficiency of LNG transportation via pipelines or tankers is far less than that of oil, meaning far more transportation costs for LNG. So, natural gas prices are regional, having yet to be globalized. Natural gas or LNG has thus failed to develop into any financial instrument in regions other than the United States and Western Europe.

Factors forming natural gas prices

Natural gas commoditization has relatively failed to make progress over the last few decades. The supply-demand balance (particularly in Asia and Europe), crude oil prices and risks are factors forming prices for natural gas. These factors are considered more important than market participants' expectations that play a significant role in setting oil prices. Unlike crude oil, natural gas has no global benchmark prices and factors forming natural gas prices work on a region-by-region basis. These regional natural gas prices influence each other through international trade. In the following, we analyse the international natural gas price formation, and discuss domestic natural gas prices to the extent they influence international prices.

Supply and demand factors are the most important among factors forming natural gas prices over a medium to long term.

While macroeconomic conditions and population define overall energy demand, natural gas use promotion measures, infrastructure development, CO_2 prices (that have the most remarkable impact in Europe among regions) and technological innovation influence the price competitiveness of natural gas against rival fuels and define natural gas demand. Particularly, economic growth in China, India, ASEAN (Association of Southeast Asian Nations) members and other emerging countries is very important on the demand side.

In Europe, natural gas prices have been stable since 2009. The average wholesale gas price known as the National Balancing Price in the U.K. gas market that is the most liquid in Europe reached $11 per million British thermal units (MBtu) in 2008 and plunged to $4.9/MBtu in 2009. Since then, prices other than temporarily high prices caused by cold waves have never recovered the 2008 peak. The price trend is common to major West European natural gas consuming countries including Germany. This is because macroeconomic conditions have deteriorated on financial and sovereign debt crises and natural gas has lost competitiveness against renewable energy sources supported by policies and against coal whose consumption has expanded due to slumping CO_2 prices. Similarly, China has seen slowing growth in natural gas demand and has been considering lowering regulated natural gas prices as of autumn 2015 due mainly to economic deterioration growing remarkable in 2015 and natural gas's loss of price competitiveness.

On the supply side, the shale revolution may be the most important factor, as is the case with crude oil. The U.S. Henry Hub natural gas price has remained low below $3/MBtu up to October 2015. Whether productivity could be improved further to justify continuous investment even at the price level and whether the shale revolution would be realized in Canada, China, Argentina and Mexico may be important.

The United States has had a typical case in which supply factors have influenced natural gas prices. As is well known, a technological innovation combining hydraulic crushing, horizontal drilling and three-dimensional geological mapping has dramatically reduced shale gas production costs. The cost reduction stimulated progress in investment in shale gas development, leading shale gas output to expand rapidly. As demand growth failed to catch up with output growth, the Henry Hub price plunged to less than $3/MBtu in 2015 from a peak of $13/MBtu reached in July 2008. Technological innovations have been faster than the loosening of the supply-demand balance, allowing shale gas to maintain its competitiveness. Whether technological innovation could be continued in the future may greatly influence U.S. natural gas prices.

Prices for crude oil that account for most of international energy transactions exert great influences on those of petroleum products and electricity, or on prices in general, as fuel or materials costs. While supply and demand, finance, economy and risk factors form crude oil prices as explained above, crude oil prices directly influence natural gas prices because of natural gas supply contracts for Asia and Central and Eastern Europe that mostly link prices to oil prices. The link to oil prices takes various forms depending on the degree of the link (pricing formula tilt) and the presence or absence of an "S curve" mechanism for mitigating extreme price fluctuations. Therefore, how and when crude oil prices influence natural gas prices in individual contracts for the oil price link cannot be generalized.

Japan LNG Cocktail (JLC) prices in the 2000s indicate a remarkable case in which oil prices greatly influenced natural gas prices. The JLC price was almost equal to the Japan Crude Cocktail (JCC) price in 2000 and was limited to some 70% of the JCC price in 2007 despite a sharp crude oil price hike as the "S curve" and other mechanisms adopted for many contracts for LNG for Japan worked to restrict LNG price hikes even amid the oil price upsurge. LNG thus improved its price competitiveness against petroleum products in this way, allowing Japan's city gas demand to grow in the decade.

While supply and demand factors and crude oil prices define a medium to long-term price trend for natural gas, abnormal weather, natural disasters, accidents, terrorist attacks, walkouts, armed conflicts and other risk factors cause relatively short-term price volatility in most cases. Since the Middle East's share of natural gas exports in the global market is relatively small, the Middle Eastern situation exerts less direct impact on international natural gas prices than on crude oil prices. Through the oil link, however, the Middle Eastern situation could work to push up natural gas prices for Asia and Europe.

In the most remarkable case in which a risk factor brought about a major price fluctuation for natural gas, hurricane damage caused a sharp natural gas price hike in the United States in 2005. Great Hurricanes Katrina and Rita hit the Gulf of Mexico in August and September 2005, respectively, bringing about the largest ever natural disaster in the United States. As the hurricanes drowned, damaged or destroyed gas/oil drilling rigs in the gulf, the loss of gas production capacity totalled up to 8.8 billion cubic feet per day. As a result, the Henry Hub natural gas price soared from the July 2005 average of $8/MBtu to the October 2005 average of $13/MBtu.

Natural gas pricing methods

International natural gas pricing methods differ from region to region. Asian natural gas prices are generally linked to the JCC price. United States and United Kingdom natural gas prices are linked to Henry Hub and NBP domestic wholesale prices, respectively. Although Continental Europe had generally linked natural gas prices to petroleum product and Brent crude oil prices, Germany and other major West European gas importing countries have linked their natural gas prices to domestic wholesale prices, as is the case with the United States and the United Kingdom.

Natural gas prices' link to oil prices originated from business practices in Northwest Europe in the 1960s. In a bid to locally consume natural gas from the Groningen gas field discovered in the Netherlands in 1959, gas field developers and the Dutch government linked the prices of natural gas to those of petroleum products, assumed to compete with natural gas, to achieve both the diffusion of natural gas and the maximization of natural gas sales income. The concept of natural gas prices linked to oil prices successfully diffused natural gas in Europe, leading gas exporting countries Norway, Russia and Algeria to follow the oil-linked natural gas pricing method.

Asia has also followed the concept of natural gas prices linked to oil prices. Fixed prices reflecting production and liquefaction costs had been adopted for early-stage LNG imports from Alaska and Brunei. As crude oil prices were destabilized, however, LNG prices for Japan shifted to the oil price link in the 1970s. Reference crude oil prices for LNG prices had initially included OPEC's posted price and oil producing countries' government selling prices. As these government selling prices deviated from spot crude oil prices in the 1980s, doubts emerged about the advisability of linking LNG prices to crude oil prices announced by oil producing countries. Therefore, the JCC price replaced government selling prices as the reference for LNG prices in the 1990s. The link to oil prices has seemingly been adopted for pipeline gas transactions within the ASEAN region and for China as well.

When LNG prices for Asia posted an unprecedented excess (the so-called Asian premium) over those for Europe and the United States in the 2010s, however, doubts emerged about the advisability of linking LNG prices to oil prices. As the oil price plunge since the second half of 2014 has worked to lower LNG prices linked to oil prices, the Asian premium has shrunk. But the unreasonableness of LNG prices rising in line with oil price hikes irrespective of supply and demand conditions for LNG or natural gas has still been left untouched.

At present, hybrid contracts that include European and U.S. gas hub prices or spot LNG prices into LNG pricing formulas are increasing. Prices for LNG imports from the United States will be linked to the Henry hub price. In this way, the diversification of gas pricing formulas has been making progress. For a medium to long term, it will be desirable for natural gas prices for Asia to be based on LNG or natural gas supply and demand conditions. The improvement of LNG market liquidity in LNG importing countries and the repeal or relaxation of the destination clause in the international market will be required to allow any benchmark Asian natural gas price to be formed.

Price assumptions

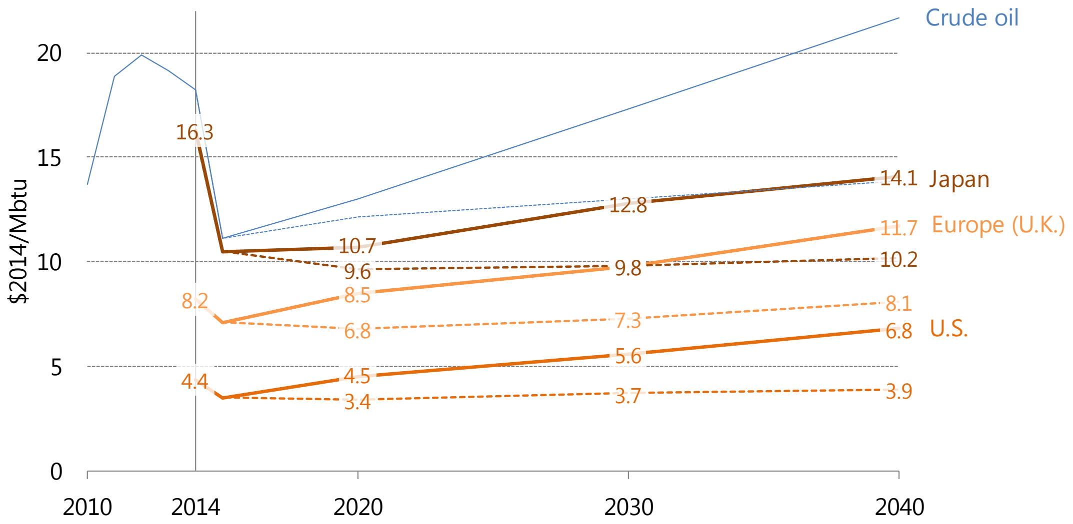
Background for Reference Scenario

In the *Reference Scenario*, the natural gas price in 2020 is assumed at $4.5/MBtu for the United States (Henry Hub), at $8.5/MBtu for the United Kingdom (NBP) and at $10.7/MBtu for Japan (JLC). The price in 2040 is put at $6.8/MBtu for the United States, at $11.7/MBtu for the United Kingdom and at $14.1/MBtu for Japan. On the demand side, natural gas consumption in the power generation and transport sectors, energy conservation, infrastructure development and natural gas use promotion policies will make progress as recognized at present. On the supply side, unconventional gas will continue to account for half of total output in the United States. Unconventional gas development in other countries will not make progress before 2025. Reflecting the loosening LNG supply-demand balance, the JLC price will stay around $10/MBtu until 2020 and rise slowly later. As a result, interregional gas price gaps will narrow to some extent.

Background for Lower Price Scenario

In the *Lower Price Scenario*, United States, United Kingdom and Japanese natural gas prices are assumed to rise little in real terms. On the demand side, energy conservation will diffuse considerably not only in advanced countries but also in emerging countries and be combined with the utilization of non-fossil fuels to restrict natural gas consumption in the power generation sector. On the supply side, unconventional gas production costs will dramatically decline on technological development. Unconventional gas will continue to account for more than half of total natural gas output in the United States and unconventional gas development in other countries will begin to make progress after 2020. The natural gas price in 2020 is assumed at $3.4/MBtu for the United States, at $6.8/MBtu for the United Kingdom and $9.6/MBtu for Japan. The price in 2040 is put at $3.9/MBtu for the United States, at $8.1/MBtu for the United Kingdom and $10.2/MBtu for Japan. As a result, interregional natural gas price gaps will narrow further.

Figure 26 Natural gas prices assumptions



Solid lines: Reference Scenario, Dotted lines: Lower Price Scenario.

In both scenarios, the natural gas pricing formulas for Asia are assumed to make progress in diversification while falling short of shifting away completely from the link to oil prices. If domestic and international gas market liquidity is improved in Asia, with LNG prices fluctuating more wildly than oil prices, Asia may shift away from the oil price link to importing countries' wholesale gas prices or spot LNG prices.

Part II

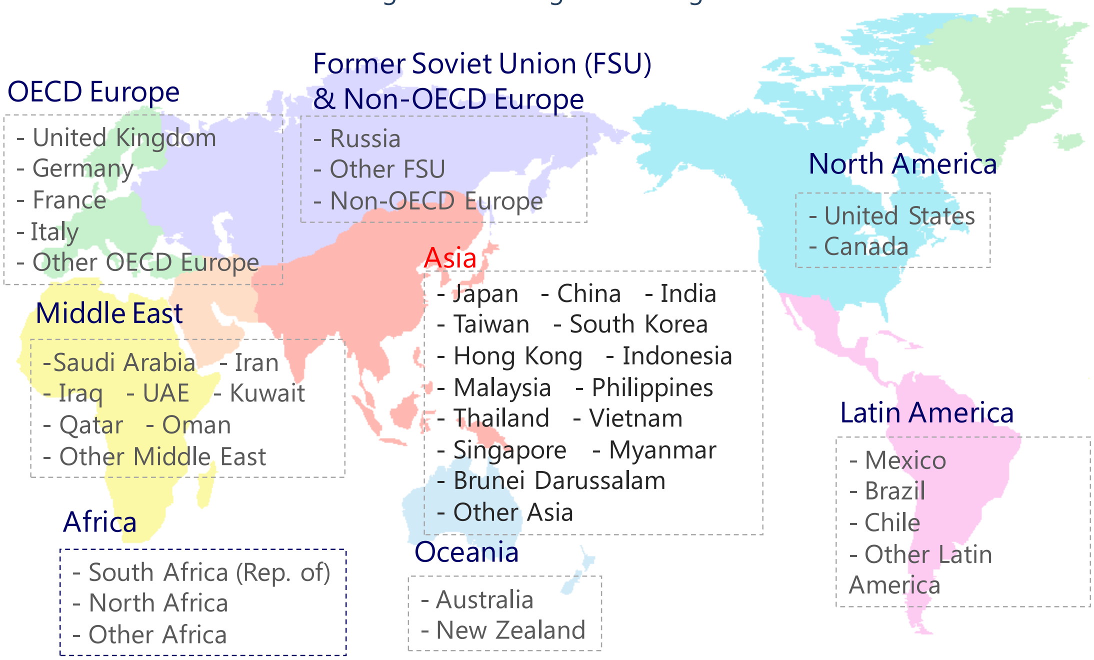
Asia/World energy demand and supply outlook

2. Major assumptions

2.1 Model and scenarios

We used a quantitative analysis model with an econometric approach adopted as the core to develop an energy supply and demand outlook to quantitatively assess energy supply and demand in the world through 2040. The model, based on the energy balance tables of the International Energy Agency (IEA), covers various economic indicators as well as population, vehicle fleet, materials production and other energy-related data collected for modeling. We aggregated the world into 42 regions as indicated in Figure 27, built a detailed supply and demand analysis model for each region and made the projection.

Figure 27 Geological coverage



We assumed the following three scenarios for the projection.

Reference Scenario

This is the core scenario for this Outlook. For this scenario, a future outlook is developed according to the past trends as well as the energy and environment policies that have been in place so far. Only traditional and conventional policies are incorporated into this scenario. We assumed that any aggressive energy conservation or low-carbon policies deviating from the past ones will not be adopted in this scenario.

Advanced Technologies Scenario

In this scenario, all countries in the world are assumed to strongly implement energy and environment policies helping to secure stable energy supply and enhancing climate change measures, with these policies' effects being successfully maximised. Specifically, our projection is based on an assumption that advanced technologies for the energy supply and demand sides as given in Figure 28 will be introduced as much as possible, with their application opportunities and acceptability taken into account.

Figure 28 Assumptions for the Advanced Technologies Scenario

【Demand Side Technology】

■ Industry

Under sectoral and other approaches, best available technologies on industrial processes (for steelmaking, cement, paper-pulp and oil refining) will be deployed globally.

■ Transport

Clean energy vehicles (highly fuel efficient vehicles, hybrid vehicles, plug-in hybrid vehicles, electric vehicles, fuel cell vehicles) will diffuse further.

■ Building

Efficient electric appliances (refrigerators, TVs, etc.), highly efficient water-heating systems (heat pumps, etc.), efficient air conditioning systems and efficient lighting will diffuse further, with heat insulation enhanced.

【Supply Side Technology】

■ Renewable Energy

Wind power generation, photovoltaic power generation, CSP (Concentrated Solar Power) generation, biomass power generation and bio-fuel will diffuse further.

■ Nuclear Energy Promotion

Nuclear power plant construction will be accelerated with operating rates improved.

■ Highly Efficient Fossil-fired Power Plant Technology

Coal-fired power plants (USC, IGCC, IGFC) and natural gas MACC (More Advanced Combined Cycle) plants will diffuse further.

■ CCS

CCS deployment will expand in the power generation sector (new and old coal-fired and gas-fired plants) and the industrial sector (steelmaking, cement and other plants that emit massive GHGs).

Lower Price Scenario

In this scenario, the global oil supply-demand balance is assumed to ease as energy and environmental measures for securing stable energy supply and enhancing climate change measures are implemented on the demand side as strongly as in the *Advanced Technologies Scenario* to limit fossil fuel consumption and as unconventional oil and gas development makes progress on the supply side. The real crude oil price in 2030, which is assumed to rise back to $100/bbl in the *Reference Scenario*, is put at $75/bbl in the *Lower Price Scenario*.

Following are other major assumptions:

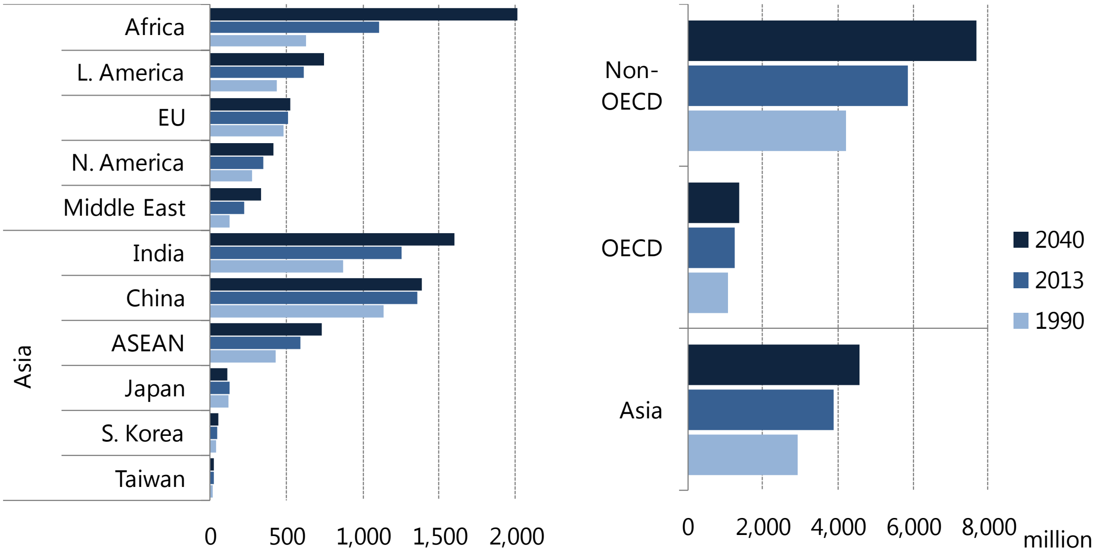
2.2 Major assumptions

The future energy supply and demand structure will be subject to population, economic growth and other social and economic factors, as well as energy prices, energy utilisation technologies, and energy and environment policies. The following assumption for population is common to all the scenarios.

Population

In assuming population changes, we referred to the United Nations' "World Population Prospects". In many OECD countries where the total fertility rate (TFR), or the average number of children that would be born to a woman during her lifetime, has slipped below 2, downward pressure on population will increase. In non-OECD countries as well, the TFR is trending down in line with income growth and women's increasing social participation. But their population will continue increasing as the mortality rate is declining due to developing medical technologies and improving food and sanitation conditions. Overall, global population will increase at an annual rate of 0.9%, expanding to 9 billion in 2040 from 5.3 billion in 1990 and 7.1 billion in 2013 (Figure 29, Appendix Table 3).

Figure 29 Population



Among OECD countries, North America, particularly the United States, will post a relatively steady population increase due to a massive population influx from abroad and a high TFR. But the increase will be moderate, with the United States' share of global population falling slightly. In Europe, population will decrease for Germany and Italy while increasing moderately for France and the United Kingdom. The total population of the European Union will increase very moderately. Among Asian countries, Japan has seen a population decline since 2011 and will post the fastest population fall in the world in the future. In 2015, the elderly population grew to more than double the young population, indicating a further fall in the birth rate and further population aging in the future. In Korea, population will peak out in the middle of the 2030s.

Most non-OECD countries will see population continuing to increase. Non-OECD countries will account for most of a global population increase through 2040. Africa is expected to post a rapid annual population increase of 2.3%, still slower than the past population explosion, as many countries in the region see continued high birth rates. The Middle Eastern population will expand about 1.5-fold in the next 25 years due to governments' financial incentives for increasing population and a growing population influx from other regions. In Asia, India will maintain a high population growth rate, with its population surpassing Chinese population in the middle of the 2020s. In 2040, India will have the world's largest population at 1.59 billion. Population in the Association of Southeast Asian Nations (ASEAN) has far exceeded European population and will increase at a pace only second to India's. Meanwhile, China's population, now the largest in the world, will peak at 1.41 billion around 2030 and decrease by more than 20 million toward 2040. China is the only country with more than 100 million elderly people aged 65 or more and will see further population aging. As the young population concentrates in urban regions, rural population aging will grow more serious. In Europe, Russia, plagued with a population fall since the collapse of the Soviet Union, will see a continuous downward trend. Population in Eastern European countries will decline faster than in Russia.

Asia as a whole will see a continuous population increase. But its share of global population will slowly decline. The share in 2040 will be half down from 55% in 2013.

Economy

Annual global economic growth over the next 27 years in the *Reference* and *Advanced Technologies Scenario*s is assumed at 2.9%.

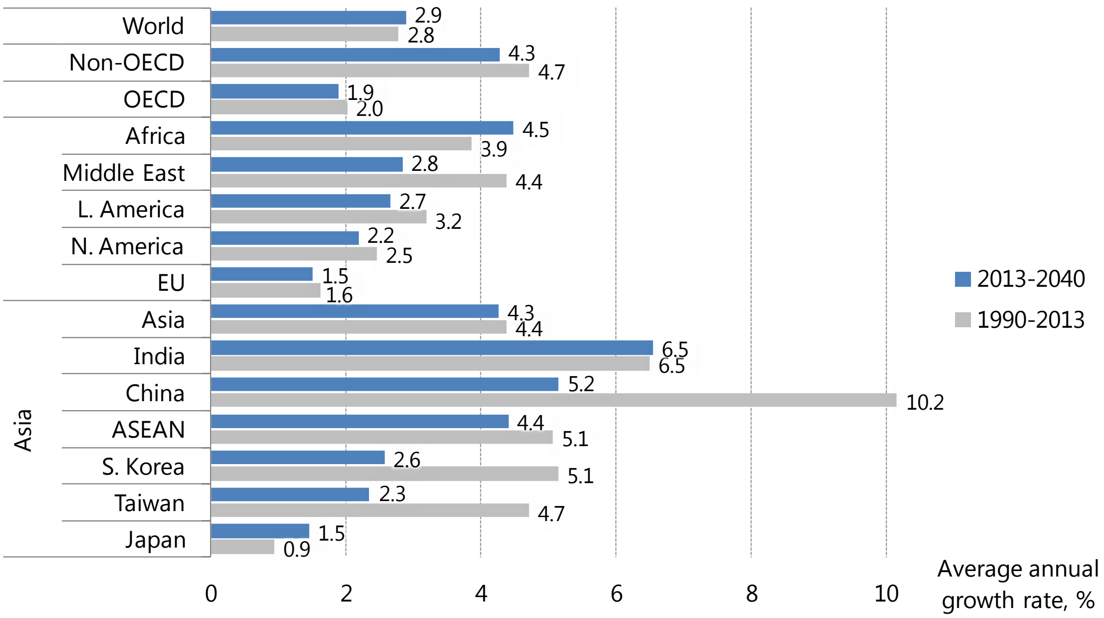
At present, the future course of the world economy is growing uncertain. In the United States, the largest economy in the world, a domestic demand expansion through robust private consumption stimulated by low crude oil prices and the falling unemployment rate is supporting an economic recovery. But an external demand slump under the dollar's appreciation is dragging down economic growth. In the European economy, second to the U.S. economy, private consumption has been recovering thanks to low oil prices, the euro's depreciation and low interest rates. But slack non-residential investment and destabilizing factors such as the Greek debt problem are exerting downward pressure on economic growth. The Chinese economy, the third largest after the United States and Europe, has decelerated its annual growth to around 7% due to decelerated exports to Japan, Europe and ASEAN under its declining export competitiveness through rising labour costs, slack real estate investment and weak private consumption accompanying the termination of measures for spreading energy-saving home electrical appliances. In the middle of 2015, financial market turmoil emerged in China and spilled over to the rest of the world. Asian emerging economies, which had maintained their growth through exports to China, look less strong than in the past. The decelerating Chinese demand is dragging down economic growth in Singapore, Malaysia and Thailand where exports to China account for large shares of total exports. Oil producing and resource-rich economies like Russia, the Middle East and Latin America have deteriorated due to weak oil prices over a short term.

However, many economies are likely to rebound through appropriate fiscal and monetary policies and concerted international actions over a medium to long term. In the future, India will increase its presence as a new driver of global economic growth. Over the 27-year outlook period, the Indian economy will grow at the world's fastest annual pace of 6.5%. Over a medium to long term, structural reform and export growth through a global economic recovery will support India's economic growth. Given that India's exports to China account for only 8% of its total exports and 2% of its gross domestic product, India will remain unaffected by the current economic growth deceleration in China. China, even with the current economic growth slowdown, is expected to maintain an annual economic growth rate of 5.2%. The ASEAN economy will grow at an annual rate of 4.4%.

In this way, Asia is expected to remain the centre of global economic growth after achieving strong growth. But rising wages and citizens' growing consciousness of rights will force Asia to switch away from export-oriented economic growth that takes advantage of abundant surplus labour and low costs. While the current economic growth deceleration does not necessarily indicate any limit on their future growth, the current environment has changed from the past one that supported high economic growth in Asian emerging countries including China. They are required to take precautions against the so-called middle income country trap.

In consideration of the above-explained situation, as well as of the economic outlooks of the Asian Development Bank and other international organizations, and each government's economic development programs, we assumed real GDP growth rates as in Figure 30 and Appendix Table 4.

Figure 30 Real GDP growth



International energy prices

From the second half of 2014, a combination of demand-side and supply-side factors caused a glut in the international oil market, resulting in a steep plunge in crude oil prices. Demand-side factors include the economic growth deceleration in Europe and China, and the supply-side factors include crude oil output expansion in the United States and Libya as well as OPEC's decision against oil output cuts to ease the supply-demand balance. In response to a decline in the number of operating oil drilling rigs and decelerating oil output growth in the United States, the key Brent crude oil futures price seemingly hit bottom at $48/bbl in January 2015 and rose back to $64/bbl in May. But the price fell back to $47/bbl again in August as OPEC again decided not to cut oil output in June and as Iranian crude oil exports were growingly expected to increase on Western countries' possible termination of economic sanctions on Iran following Iran's agreement to limit its nuclear development in July.

In the *Reference* and *Advanced Technologies Scenario*s, oil demand is assumed to continue increasing in line with firm global economic growth over a medium to long term. While United States and other non-OPEC oil output will continue an upward trend on the supply side, oil importing countries will still be heavily dependent on OPEC and Russia plagued with geopolitical risks. At the same time, marginal oil production costs will rise on a shift to small and medium-sized, polar and ultra-deep-sea oil fields where production costs are relatively higher. Any tough restrictions on excessive money inflow into the futures market are unlikely to be introduced, indicating speculative investment money could push up oil prices. Given these factors, crude oil prices are expected to fluctuate wildly over a short term and gradually rise over a medium to long term. The real crude oil price (in 2014 prices) is assumed to increase to $75/bbl in 2020 and $125/bbl in 2040 (Table 4). Under an annual inflation rate of 2%, the nominal price is projected to reach $84/bbl in 2020 and $209/bbl in 2040.

In the *Lower Price Scenario*, major U.S. oil fields will grow more competitive to produce profit even at low oil prices with OPEC countries increasing output on the supply side. On the demand side, most countries in the world will strongly tackle climate change measures to restrict fossil fuel consumption. In the *Lower Price Scenario*, the real crude oil price is assumed to stand at $70/bbl in 2020 and $75/bbl in 2030.

Natural gas prices in the *Reference Scenario* will rise from current record-low levels in line with development and production cost hikes, although they will remain low in the United States. In Japan, however, incoming unconventional natural gas imports from the United States will contribute to eliminating or easing the problem of the so-called Asian premium on LNG prices. In contrast to rising natural gas prices in the United States and Europe, the LNG price in Japan will fall from $16.3/MBtu in 2014 to $14.1/MBtu toward 2040. But the price in Japan will still be higher than in Western countries due to certain limits on liquefaction and maritime transportation cost cuts. In the *Lower Price Scenario*, natural gas prices will decline in line with weak crude oil prices toward 2020 in Western countries as well and rise gradually later.

Coal prices are low at present, reflecting the loose supply-demand balance. In the *Reference Scenario,* coal prices are assumed to rise faster than crude oil and natural gas prices due to growing global demand for coal for power generation and a rebound from the current low levels, despite less resource constraints for coal. But prices per thermal unit for coal will still be lower than those for crude oil or natural gas. In the *Lower Price Scenario*, coal price hikes will be limited to moderate levels in response to a loose supply-demand balance in the international energy market.

Table 4 Primary energy prices

Real prices			2014	Reference 2020	Reference 2030	Reference 2040	Lower Price 2020	Lower Price 2030	Lower Price 2040
Crude oil		$2014/bbl	105	75	100	125	70	75	80
Natural gas	Japan	$2014/MBtu	16.3	10.7	12.8	14.1	9.6	9.8	10.2
	Europe (UK)	$2014/MBtu	8.2	8.5	9.8	11.7	6.8	7.3	8.1
	United States	$2014/MBtu	4.4	4.5	5.6	6.8	3.4	3.7	3.9
Steam coal		$2014/t	98	89	106	132	86	96	108

Nominal prices			2014	Reference 2020	Reference 2030	Reference 2040	Lower Price 2020	Lower Price 2030	Lower Price 2040
Crude oil		$/bbl	105	84	137	209	79	103	134
Natural gas	Japan	$/MBtu	16.3	12.0	17.6	23.6	10.8	13.5	17.1
	Europe (UK)	$/MBtu	8.2	9.6	13.5	19.6	7.7	10.0	13.6
	United States	$/MBtu	4.4	5.1	7.7	11.4	3.8	5.1	6.5
Steam coal		$/t	98	100	145	221	97	132	181

Note: Nominal prices assume inflation of 2% per year from 2014.

3. Energy demand

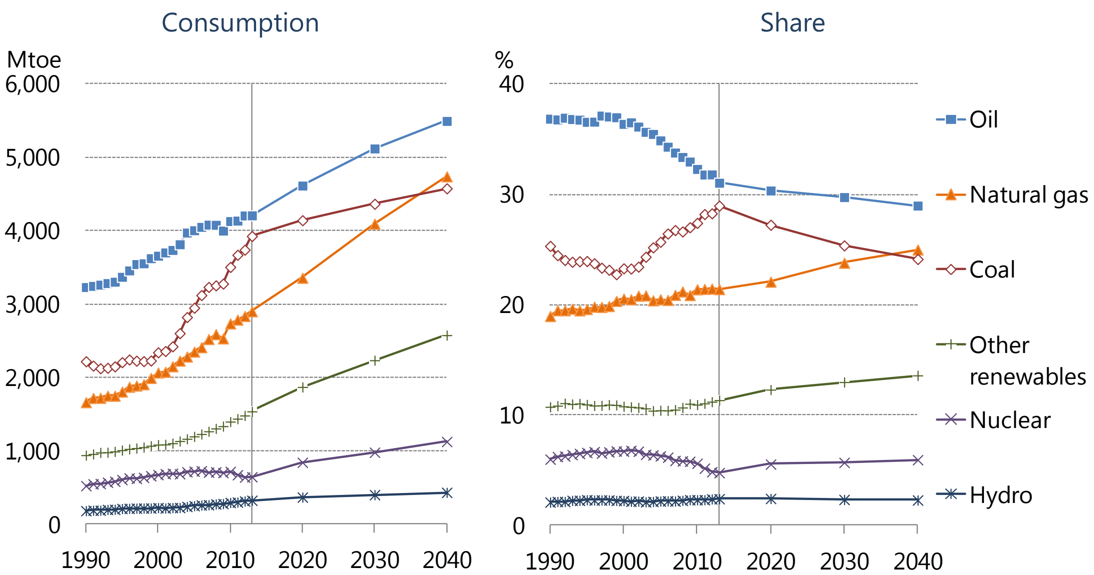
3.1 Primary energy consumption

World

The growth in world primary energy consumption is decelerating in response to a slowdown in the world economy. In the *Reference Scenario* where social, economic, policy and technology introduction trends involving energy supply and demand are assumed to continue, global primary energy consumption will increase by 5,408 million tonnes of oil equivalent (Mtoe) from 13,555 Mtoe in 2013 to 18,963 Mtoe in 2040. The increase will exceed the combined current consumption in the United States as the world's largest energy consumer and China as the second largest. In the 27-year outlook period, the world economy will grow 2.2-fold with energy consumption increasing 1.4-fold, meaning that energy conservation will restrict energy consumption to a lower level than indicated by economic growth. This also indicates how difficult it would be to limit energy consumption while promoting economic growth with the presently anticipated national energy policies and energy-saving technologies taken into account.

At present, fossil fuels (oil, coal and natural gas) account for 81% of primary energy consumption. They will still capture more than 70% of future consumption growth and account for 78% of global primary energy consumption in 2040. The world will thus remain heavily dependent on fossil fuels (Figure 31).

Figure 31 Global primary energy consumption by source [Reference Scenario]



Oil's share of primary energy consumption will shrink from 31% in 2013 to 29% in 2040 due to a switch from oil to natural gas and other fuels and progress in energy conservation in the transport sector. But it will remain the most consumed energy source. Global oil consumption will expand from 87.1 million barrels per day (Mb/d) in 2013 to more than 100 Mb/d within a decade and to 113.7 Mb/d in 2040.

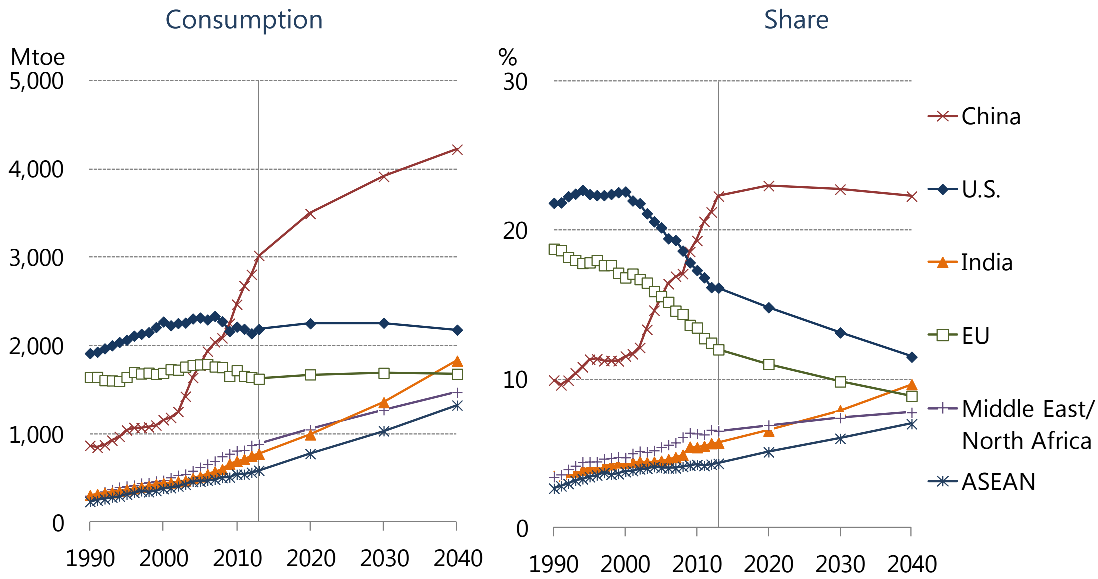
Natural gas will post the fastest consumption expansion among energy sources by 2040 due to a switch from oil to natural gas in the petrochemical industry and a switch from coal to natural gas in the power generation sector. Natural gas has become the second most consumed energy source after oil and its share of primary energy consumption will increase from 21% in 2013 to 25% in 2040. Natural gas consumption will expand 1.6-fold from 3.52 trillion cubic metres (Tcm) in 2013 to 5.75 Tcm in 2040.

Coal, though being a fossil fuel like oil or natural gas, will follow a trend that will be different from the trend for oil or natural gas. Coal consumption will grow at a slower pace than oil or natural gas consumption, as the entire world further promotes coal-saving policies to address air pollution and climate change problems. Coal's share of primary energy consumption will fall from 29% in 2013 to 24% in 2040. Global coal consumption in 2040 will total 6,539 million tonnes of coal equivalent (Mtce). The consumption growth of 928 Mtce over the 27-year outlook period will be similar to the increase of the past four years.

Hydro, geothermal, solar, wind, biomass and other renewable energies will expand their share of primary energy consumption from 14% in 2013 to 16% in 2040. Their consumption growth through 2040 will total 1,147 Mtoe, the third largest after natural gas and oil consumption growth. While solar photovoltaics and wind power generation will diffuse further, low-cost biomass and waste consumption including fuel wood and livestock manure in developing countries will account for a large share of the total growth.

Nuclear energy consumption will increase primarily in emerging countries where large amounts of electricity will be required to support economic growth. The number of countries having nuclear power plants will expand from 31 in 2013 to 41 in 2040 and nuclear energy's share of global primary energy consumption will rise from 4.8% in 2013 to 5.9% in 2040. While some OECD countries will make progress in phasing out or reducing nuclear power, nuclear energy's share of total OECD primary energy consumption in 2040 will stand at 10%, almost unchanged from 2013.

Figure 32 Primary energy consumption for selected countries/regions [Reference Scenario]



Including India and ASEAN countries where high economic growth is expected, Asia will greatly contribute to the global energy consumption growth (Figure 32). While China will continue to expand energy consumption, its share will remain unchanged from 2013. The United States and the European Union will reduce their respective shares of global energy consumption over the next 27 years.

Asia

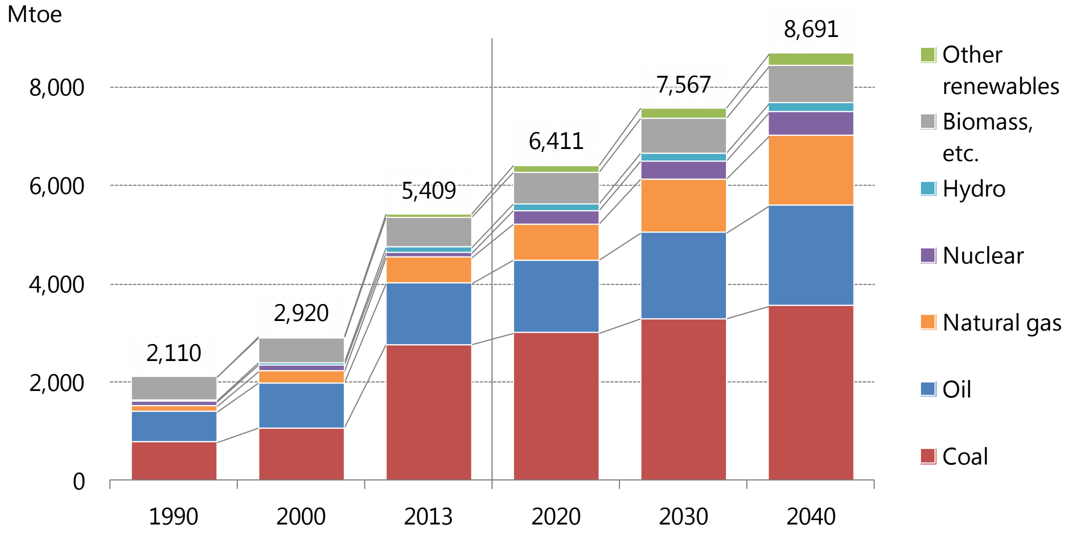
Asian primary energy consumption will expand from 5,409 Mtoe in 2013 to 8,691 Mtoe in 2040 (Figure 33). The growth of 3,281 Mtoe, equivalent to China's annual demand, accounts for 60% of the global increase. Asia's share of global primary energy consumption will rise from 40% in 2013 to 46% in 2040.

Asian primary energy consumption will grow at an annual rate of 1.8% through 2040 in line with robust economic growth mainly in China, India and ASEAN. Consumption in these countries will account for 91% of total Asian energy consumption growth and their combined share of Asian energy consumption will widen from 81% at present to 85% in 2040. Meanwhile, energy consumption will level off in mature Asian economies such as Japan, Korea and Chinese Taipei.

Fossil fuels account for 84% of Asian primary energy consumption at present and will cover 76% of the increase during the next 27 years. Asia's share of global fossil fuel consumption will rise from 41% in 2013 to 47% in 2040.

Asian oil consumption will expand from 25.9 Mb/d in 2013 to 42.5 Mb/d in 2040. The average annual growth will be 1.8%, 0.8 percentage points higher than the global growth. Oil's share of Asian primary energy consumption will level off from 23% in 2013 to 24% in 2040. Chinese, Indian and ASEAN oil consumption will expand primarily in the transport sector, accounting for 81% of total Asian consumption in 2040 against 69% in 2013.

Figure 33 Asian primary energy consumption [Reference Scenario]



Asian natural gas consumption will increase 2.7-fold from 0.65 Tcm in 2013 to 1.72 Tcm in 2040. The increase will be much faster than the global growth of 1.6-fold. Global LNG trade will expand from 239 Mt in 2014 to 547 Mt in 2040, of which Asian countries will account for 70%. China, India and ASEAN will boost natural gas consumption mainly in the power generation sector. Natural gas's share of Asian primary energy consumption will expand from 9.8% in 2013 to 16% in 2040.

Although Asian coal consumption will rise from 3,925 Mtce in 2013 to 5,065 Mtce in 2040, surpassing global growth, its share of primary energy consumption will shrink from 51% in 2013 to 41% in 2040. While China's coal consumption will decrease slightly from 2030, India and ASEAN will boost coal consumption primarily in the power generation sector, for a combined share of Asian coal consumption remaining at 90% through 2040.

Meanwhile, Asian renewable energy consumption will increase from 785 Mtoe in 2013 to 1,192 Mtoe in 2040. Asia, which has great potential to expand renewable energy consumption, will raise its share of global renewable energy consumption including hydro, geothermal, solar, wind and other energy, excluding biomass and waste, from 38% in 2013 to 45% in 2040. China will capture more than half of the Asian renewable energy consumption.

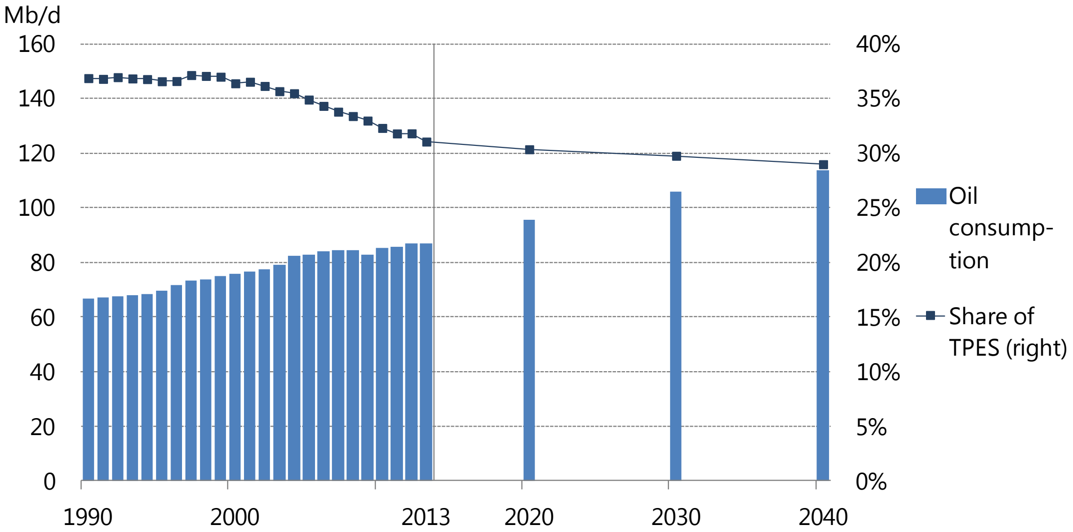
Asian nuclear power generation will increase from 340 TWh in 2013 to 1,833 TWh in 2040. Nuclear energy's share of primary energy consumption will rise from 1.6% in 2013 to 5.5% in 2040. Asia will account for 81% of global nuclear energy generation, including China and India where nuclear power generation will expand in line with sharp growth in electricity demand. Asia's share of global nuclear energy consumption will increase from 14% in 2013 to 42% in 2040, indicating Asia's growing presence in the global nuclear energy market.

Oil

Global oil consumption will rise at an annual rate of 1.0% from 87.1 Mb/d in 2013 to 113.7 Mb/d in 2040 (Figure 34). The growth of 26.6 Mb/d exceeds Middle Eastern and North

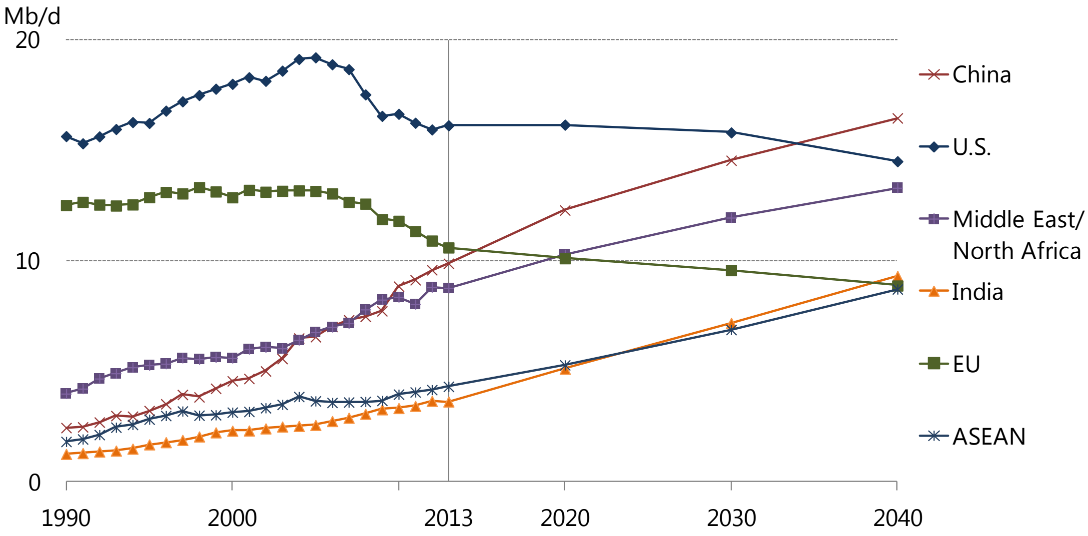
African OPEC countries' present crude oil output of 25.2 Mb/d. The transport sector including vehicles will account for 17.6 Mb/d or two-thirds of the growth. In 2040, the transport sector will account for 58% of oil consumption and petrochemical feedstocks for 15%.

Figure 34 Global oil consumption and oil's share of total primary energy supply [Reference Scenario]



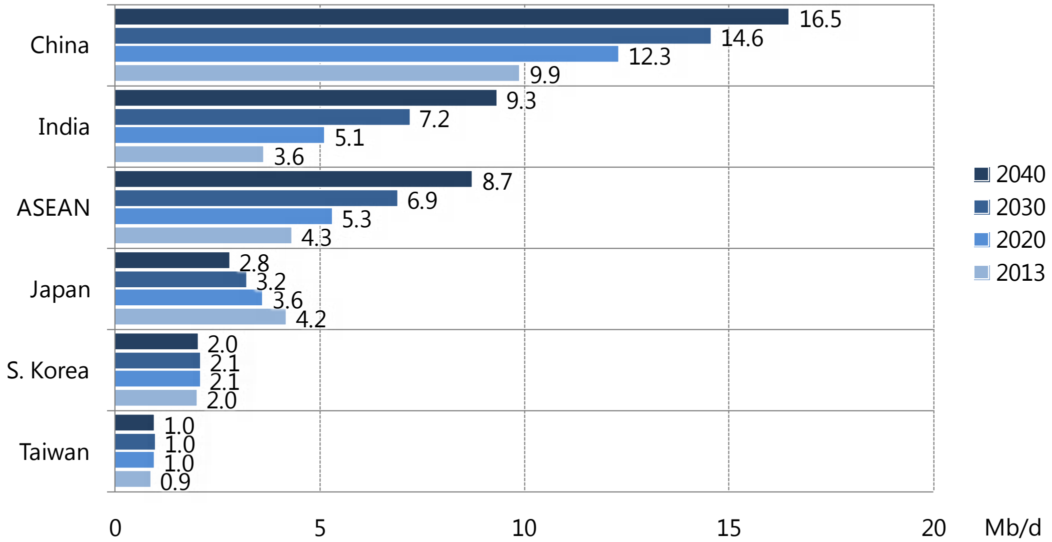
Non-OECD oil consumption exceeded OECD consumption in 2012 for the first time in history and continues to show strong growth. Over the next 27 years, non-OECD oil consumption will increase at an annual rate of 1.8% (Figure 35), while OECD oil consumption will decrease at an annual rate of 0.4%. OECD countries' share of global oil consumption will decline from 45% in 2013 to 31% in 2040.

Figure 35 Oil consumption by region [Reference Scenario]



Asia will increase its presence in the international oil market. The region will account for more than 60% of global oil demand growth boosting its share of global oil consumption from 30% to 37% in 2040.

Figure 36 Asian oil consumption [Reference Scenario]



China will become the world's largest oil importer in the near future and its oil consumption will surpass U.S. consumption by the middle of the 2030s. Indian and ASEAN oil consumption will double from 2013 to 2040. China, India and ASEAN will expand oil imports in response to domestic consumption growth while Japan and Korea, poor in domestic energy resources, will have no choice but to depend totally on oil imports. As the Asian region will depend heavily on the Middle East for oil supply, the issue of energy security will grow even more important for Asian countries.

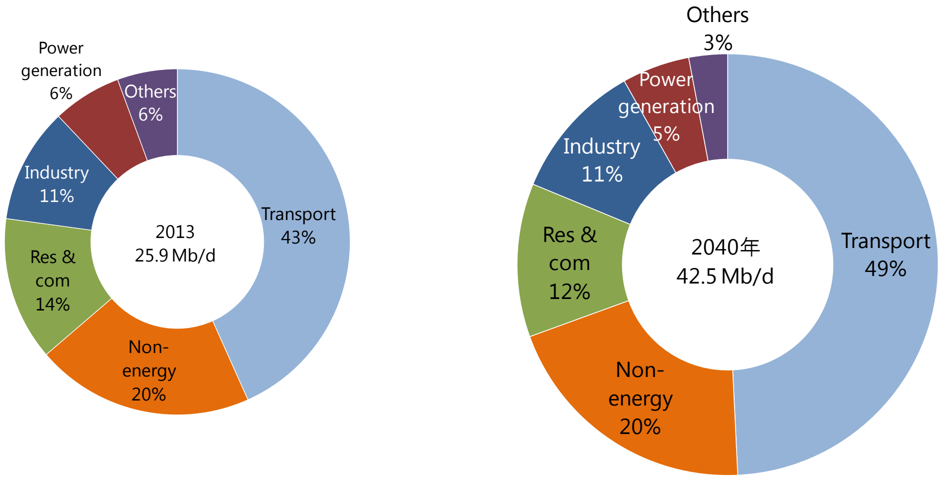
The transport sector will account for two-thirds of future oil consumption growth. Oil consumption will thus further concentrate in the transport and non-energy use sectors. Demand for lighter distillates among petroleum products will increase. The development of North American and African oil that is lighter and contains less sulphur will promote the demand shift to lighter distillates.

From the viewpoint of climate change and air pollution problems, Asia must restrict its oil consumption growth in the transport sector. The diffusion of next-generation vehicles will reduce the transport sector's energy needs and is indispensable for curbing air pollution. To address the serious growth in PM-2.5, the Chinese government has implemented a wide range of measures to support the diffusion, including the unification of standards for new-energy vehicles and recharging equipment, research and other subsidies for automakers, subsidies for vehicle purchases and tax incentives. Electric vehicles, though plagued with driving range and recharging equipment shortage problems, have begun to be used for public purposes.

Current low crude oil prices should be viewed as an opportunity to promote energy conservation in the transport sector. As Malaysia, Indonesia and other countries are reducing or eliminating fuel subsidies, they should use the savings for investment in the improvement of fuel efficiency and for the diffusion of next-generation vehicles to help curb oil consumption in the transport sector.

The transport sector's share of oil consumption in Asian countries will reach 50% in 2040 (Figure 37). The power generation sector's share of total oil consumption is limited to only 3%.

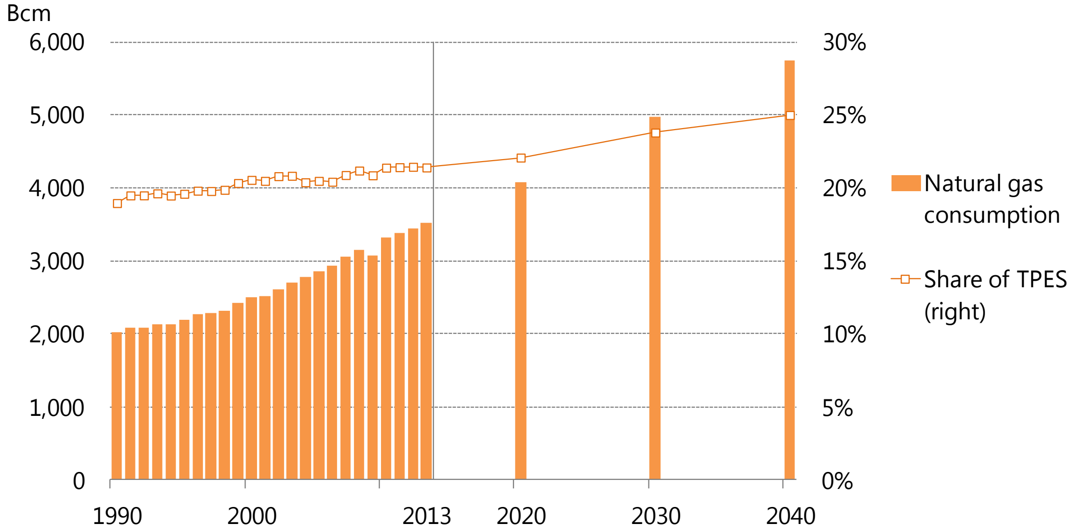
Figure 37 Asian oil consumption by sector [Reference Scenario]



Natural gas

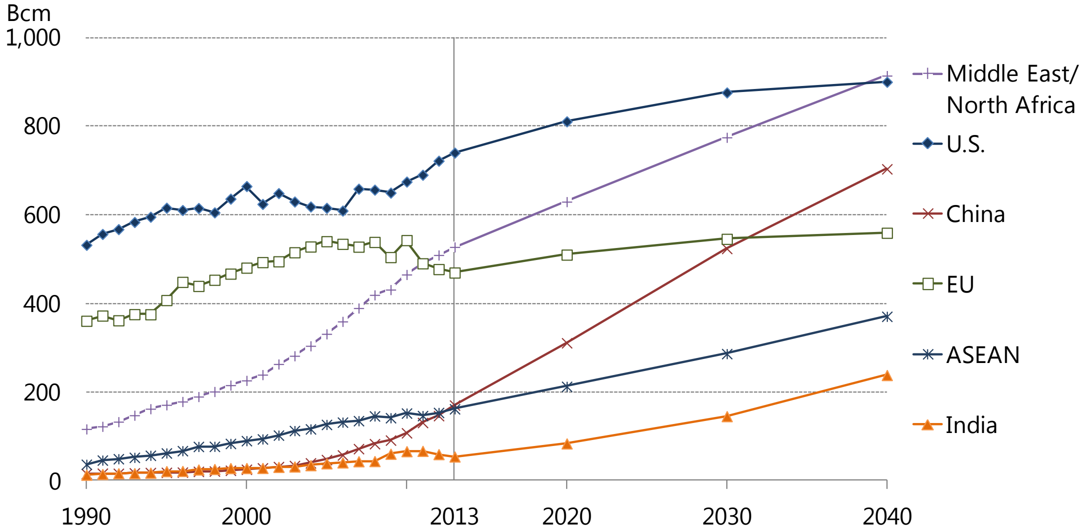
Global natural gas consumption will increase from 3,521 billion cubic metres (Bcm) in 2013 to 5,753 Bcm in 2040, scoring an annual average rise of 1.8%, the fastest growth among fossil fuels (Figure 38). Natural gas's share of primary energy consumption will expand from 21% in 2013 to 25% in 2040.

Figure 38 Global primary consumption of natural gas [Reference Scenario]



OECD countries will account for only 16% of the growth in natural gas consumption, while non-OECD countries will be responsible for the rest (Figure 39). The non-OECD share of global natural gas consumption will expand from a little more than 50% to nearly two-thirds.

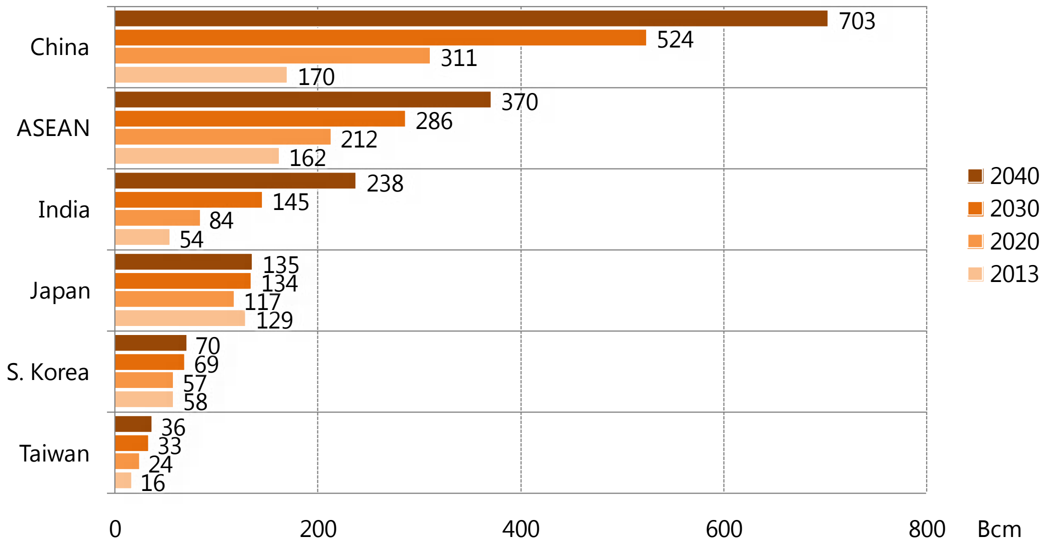
Figure 39 Natural gas consumption by region [Reference Scenario]



Among OECD countries, the United States will remarkably increase natural gas consumption. In the United States, natural gas consumption will surpass oil consumption by the mid-2030s, making natural gas the most consumed energy source. The U.S. natural gas consumption increase in the coming 27 years will total 160 Bcm rivalling the increase in India. Among non-OECD countries, China, India, and Middle Eastern and North African (MENA) countries will remarkably expand natural gas consumption. China's natural gas demand will swell by 533 Bcm in the next 27 years and India's natural gas consumption will increase by 184 Bcm during the same period. The MENA will become the world's largest natural gas consuming region by 2040, surpassing the United States.

Asian natural gas consumption will increase 2.7-fold from 646 Bcm in 2013 to 1,719 Bcm in 2040 (Figure 40). Asia's share of global natural gas consumption will rise from 18% in 2013 to 30% in 2040. Its share expansion will be the fastest among regions, indicating the extent of energy consumption growth and fuel switching in Asia. While many Asian countries will boost natural gas consumption, China alone in 2040 will consume more natural gas than is consumed now in the whole of Asia. India's natural gas consumption, though levelling off in recent years, will increase in the future mainly to support power generation and fertilizer production. India has also been promoting natural gas as fuel for public transport systems to help reduce air pollution. Japan and Korea, both major LNG importers, will increase natural gas consumption only slightly as their economies mature with non-fossil fuels utilized.

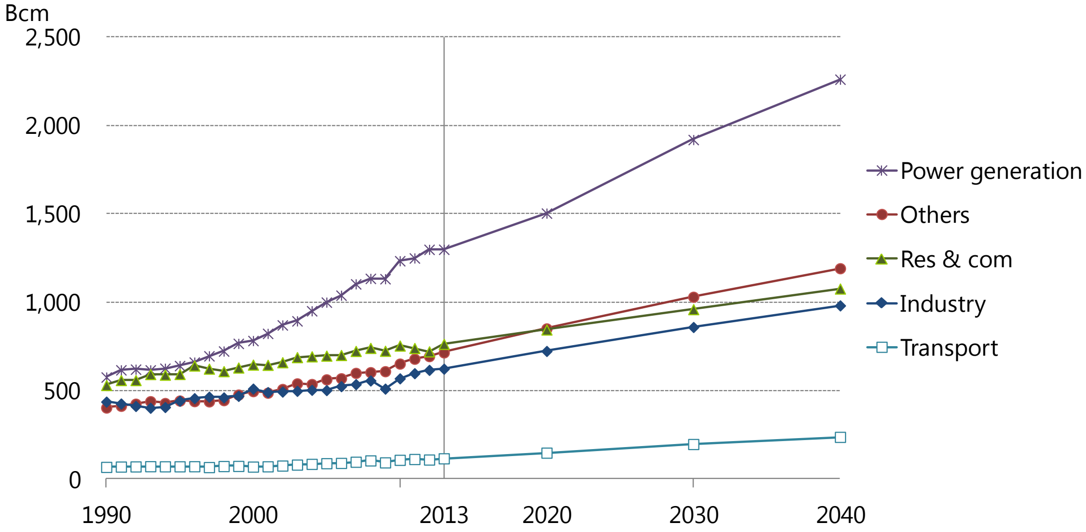
Figure 40 Asian natural gas consumption [Reference Scenario]



In the future, the Asian natural gas market will become more active. As Russia and many other resource-rich countries are looking at the Asian market, Asian countries must consider resource diplomacy and market system development to avoid any contracts that could be disadvantageous in terms of prices. They must also enhance natural gas emergency response arrangements including natural gas storage, pipelines for international or interregional gas distribution as well as flexible supply when required.

Among gas use modes, natural gas combined cycle power plants will steadily increase due to technological progress, economic efficiency and environmental considerations (oil costs more and coal causes environmental problems). As a result, the power generation sector will account for half of the natural gas consumption growth and natural gas will expand its share of global power generation to 28% in 2040, becoming the second most important electricity source after coal. In the industry sector, the petrochemical industry in the United States will take advantage of cheap natural gas for its growth, contributing to increasing natural gas consumption. But natural gas consumption for petrochemicals will exert no major influence on the whole of natural gas consumption. The building sector will also increase natural gas consumption as emerging countries promote urbanization in line with economic growth.

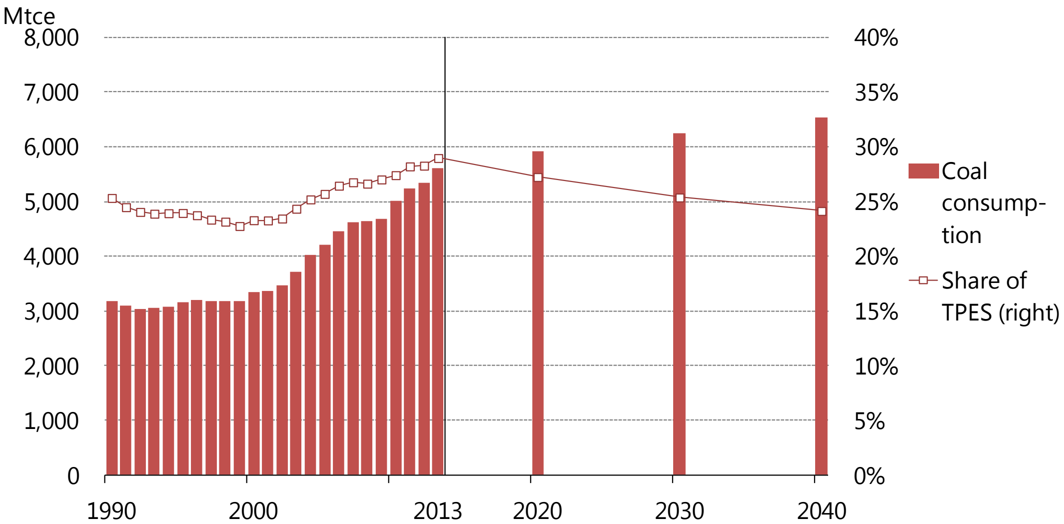
Figure 41 Global natural gas consumption by sector [Reference Scenario]



Coal

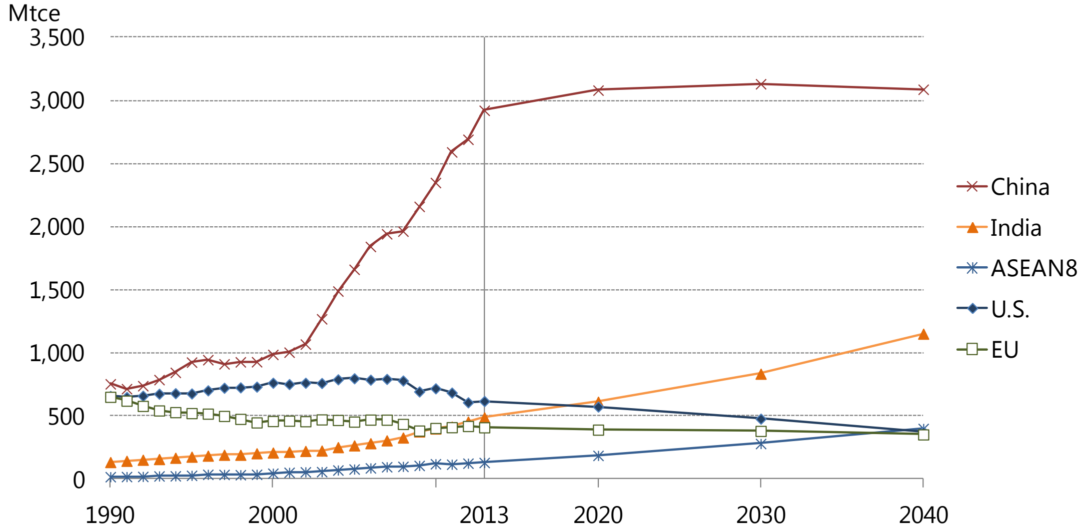
Global coal consumption will increase at an annual rate of 0.6% from 5,611 Mtce in 2013 to 6,539 Mtce in 2040 (Figure 42). Most of the increase will be for power generation.

Figure 42 Global coal consumption [Reference Scenario]



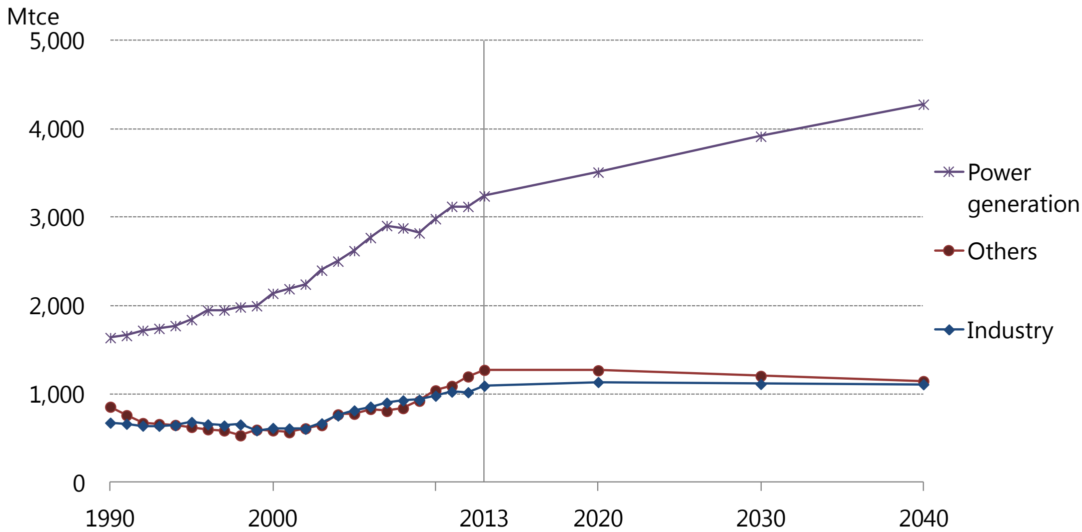
In OECD countries including the United States and European nations, increasing taxes on coal power plants and enhanced regulations on CO_2 and mercury emissions will force coal power plants to shut down. Non-OECD countries will account for all of the coal consumption growth in the next 27 years, with Asia accounting for 94% of the growth. India will replace the United States as the world's second largest coal consumer after China by 2020 (Figure 43).

Figure 43 Coal consumption by region [Reference Scenario]



Many areas in the world are endowed with coal resources so that coal has less supply risk than oil or natural gas, which are found in a limited range of regions. Due to lower prices for coal, consumption will increase mainly in the power generation sector where fuel costs are significant for economic efficiency (Figure 44). Coal consumption for power generation will increase at an annual rate of 1.3% through 2040, posting a total rise of 1.4-fold from the present level.

Figure 44 Global coal consumption by sector



In the future, more thoughts must be directed towards environmental considerations and air pollution when coal power plants are built or expanded. Some progress has been observed in this respect as China is considering shutting down inefficient small coal power plants. India has limited the ash content to 34% or less for coal for transportation beyond 1,000 kilometres to help reduce coal consumption for transportation and pulverisation at plants.

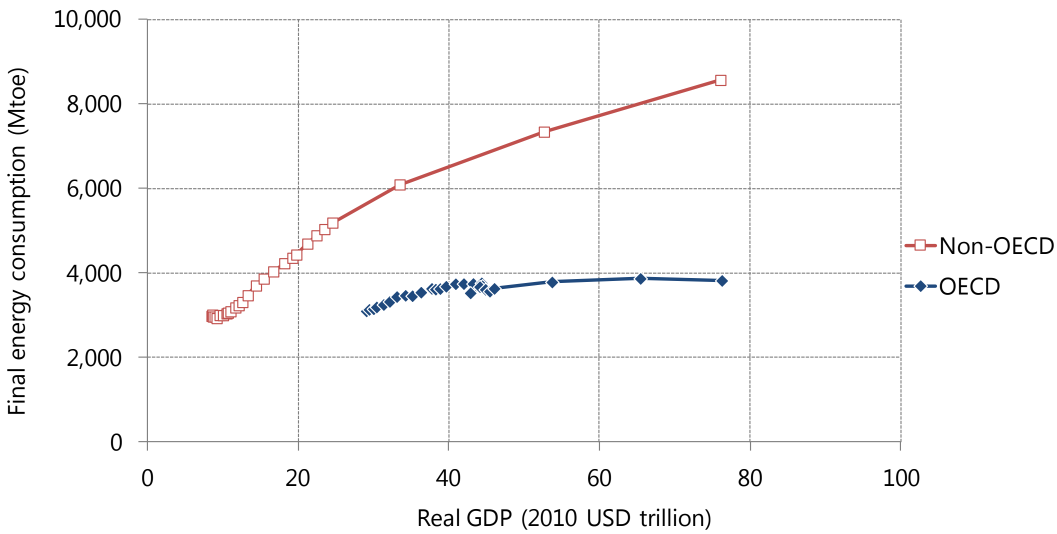
3.2 Final energy consumption

World

Final energy consumption in the world has grown at a slower pace than the world economy. Between 1990 and 2013, the annual growth in final energy consumption came to 1.7% against the annual real GDP growth rate of 2.8%. In OECD countries where energy conservation has made progress, annual final energy consumption growth was limited to 0.7% against the annual real GDP growth rate of 2.0%. In non-OECD countries, final energy consumption growth was also slower than economic growth, but was much faster than in OECD countries at 2.4% due to the high economic growth of 4.7%, growth in energy-intensive industries and increasing population. Final energy consumption will remain bipolarized between OECD and non-OECD countries. OECD final energy consumption will rise from 3,631 Mtoe in 2013 to 3,819 Mtoe in 2040 with an annual growth limited to 0.2%, while non-OECD consumption will increase at an annual rate of 1.9% from 5,188 Mtoe in 2013 to 8,564 Mtoe in 2040 (Figure 45).

Figure 45 GDP and Final energy consumption

[1990-2013, Reference Scenario: 2020, 2030 and 2040]



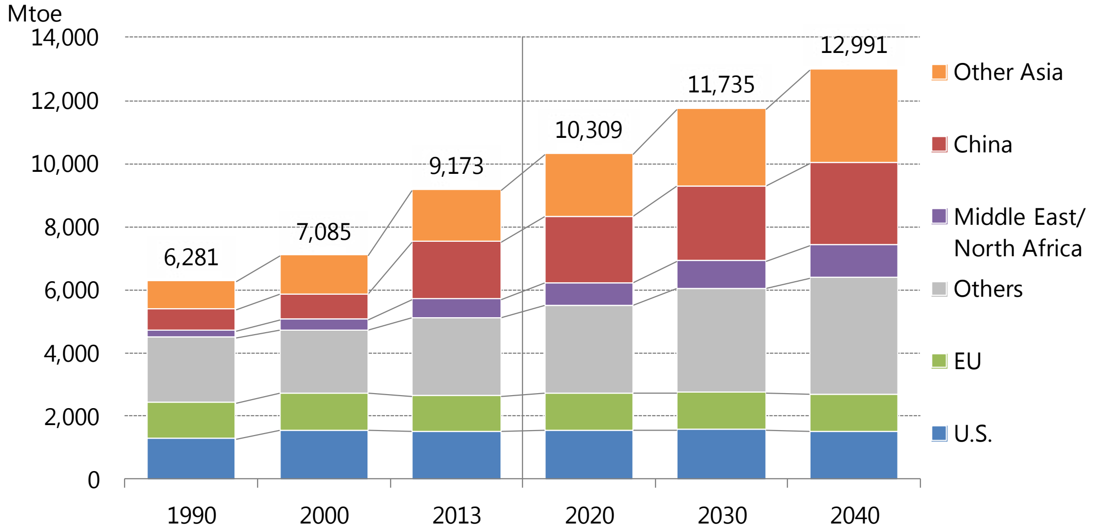
By region

Out of 3,818 Mtoe in global final energy consumption growth through 2040, Asia will account for 2,105 Mtoe or 55% (Figure 46). In Asia where high economic growth will continue, final energy consumption will increase at an annual rate of 1.8% from 3,476 Mtoe in 2013 to

5,581 Mtoe in 2040 due to the development of steel, chemical and other energy-consuming industries, progress in urbanization and improvements in living standards. In the United States and European Union where society has matured, final energy consumption will level off from 1,495 Mtoe in 2013 to 1,506 Mtoe in 2040 and from 1,139 Mtoe to 1,179 Mtoe, respectively. In the Middle East and North Africa, final energy consumption will grow from 587 Mtoe in 2013 to 1,032 Mtoe in 2040 with an annual growth rate exceeding the Chinese rate, at 2.1%. The MENA's final energy consumption growth will account for some 10% of global growth.

Of Asian countries, China and India alone will account for some 40% of global final energy consumption growth through 2040. Final energy consumption will increase at an annual rate of 1.3% or by 790 Mtoe from 2013 to 2040 in China and at an annual rate of 3.0% or by 641 Mtoe in India.

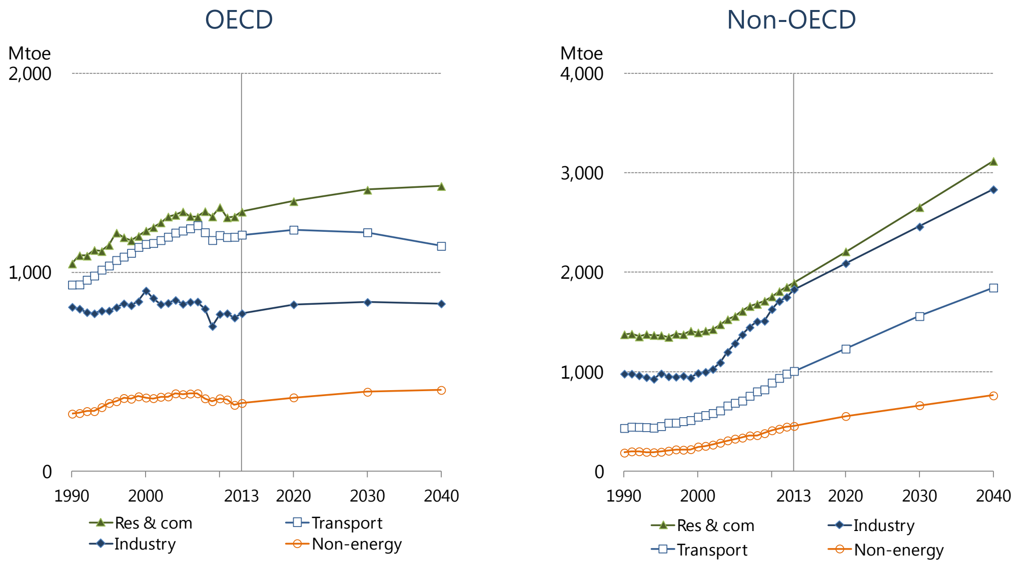
Figure 46 Final energy consumption by region [Reference Scenario]



By sector

The buildings (residential and commercial) sector will account for 1,354 Mtoe or about one-third of the final energy consumption growth of 3,818 Mtoe between 2013 and 2040 (Figure 47), followed by the industry sector with an increase of 1,054 Mtoe, the transport sector at 1,037 Mtoe and the non-energy use sector at 373 Mtoe. The annual growth rate will be 1.3% for each of those sectors. From 2013 to 2040, final energy consumption will level off in OECD countries while increasing rapidly mainly in the buildings and transport sectors in non-OECD countries.

Figure 47 Final energy consumption by sector [Reference Scenario]



In the buildings sector, non-OECD Asian countries will post an annual final energy consumption growth rate of 2.0%, higher than in any other countries or regions. As China, India and ASEAN are improving their living standards, electrical home appliances are penetrating in line with income growth. China will record a remarkable consumption increase of 334 Mtoe, exceeding Japan's annual final energy consumption.

In the industry sector, energy consumption will increase as many non-OECD countries shift from agriculture and other primary industries to steel, chemical and other energy intensive industries that consume in line with economic growth. Those countries' domestic infrastructure development and proactive call for foreign investments will further promote their industrialization. The industry sector's energy consumption will rise from 2,623 Mtoe in 2013 to 3,678 Mtoe in 2040 with Asia accounting for 60% of the 1,054 Mtoe increase.

The transport sector will increase its global energy consumption at an annual rate of 1.3% as progress in motorisation in non-OECD countries drives the consumption growth. The global vehicle fleet will expand from 1,195 million vehicles in 2013 to 2,142 million vehicles in 2040. Non-OECD Asian countries will account for 57% of the global vehicle fleet expansion. The transport sector's energy consumption will decline in OECD countries at an annual rate of 0.2% due to vehicle fuel efficiency improvements, while increasing at an annual rate of 2.3% in non-OECD countries as the effects of the vehicle fleet expansion outdo fuel efficiency improvements.

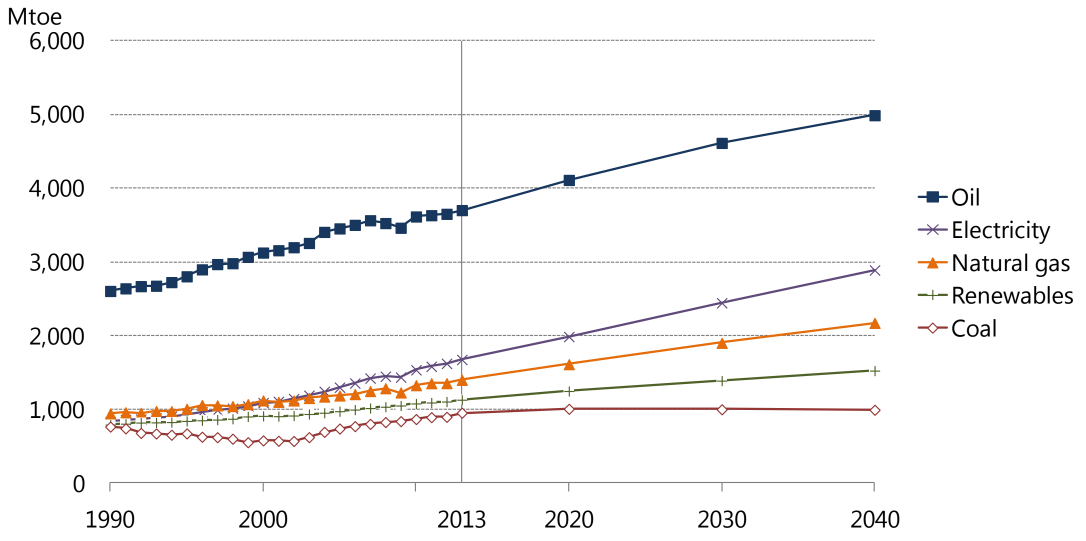
By energy source

A breakdown of final energy consumption by energy source shows that oil will score the largest consumption growth among energy sources, accounting for 34% of the final energy consumption growth. Natural gas consumption will increase substantially in China's buildings sector and the Latin American and the Middle Eastern industry sector. Electricity will post the highest growth rate among major energy sources both in OECD and non-OECD countries (Figure 48). Between 2013 and 2040, consumption will increase at an annual rate of 1.1% for oil, at 2.0% for electricity and at 1.6% for natural gas. Meanwhile, the annual growth rate for coal will be limited to 0.2%. The order of energy sources' shares of total energy consumption will remain unchanged in the outlook period. The share will fall slightly from 40% to 38% for oil and rise from 18% to 22% for electricity and from 15% to 17% for natural gas. Coal's share will shrink from 10% to 8%.

A major driver of oil consumption growth will be the transport sector in China, India and the Middle East. As gasoline and diesel oil consumption in the transport sector increases, oil consumption will shift to lighter petroleum products.

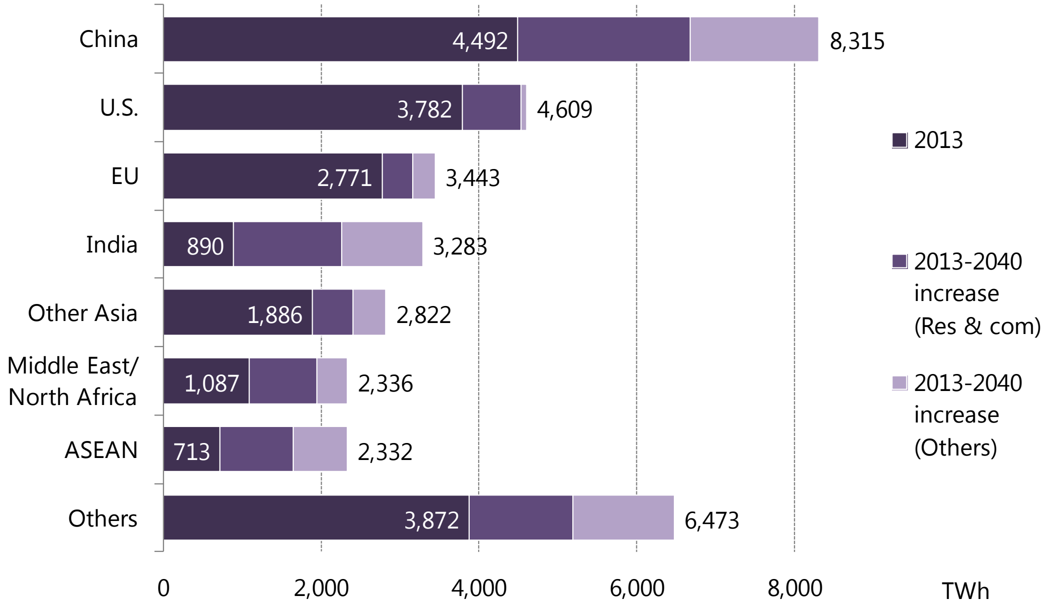
The major drivers of growth for natural gas consumption will be China's residential sector, Latin America's industry sector and the Middle East's non-energy use sector. The Chinese residential sector still uses coal and biomass fuels including firewood and will shift to city gas in consideration of health and sanitation problems. In Latin America, Brazilian and Mexican energy intensive industries such as steel, chemicals and cement will switch fuels from coal and oil to natural gas. Middle Eastern countries will promote domestic natural gas utilization while giving priority to oil exports to earn foreign currencies. They will also promote petrochemical plants using natural gas, for job creation purposes.

Figure 48 Global final energy consumption by source [Reference Scenario]



Generally, people' use of electricity is in line with income growth and this trend will remain unchanged. Electricity will score the highest consumption growth rate among major energy sources both in OECD and non-OECD countries. Driving electricity consumption growth will be Asia including China and India, as well as emerging countries like Russia and Brazil (Figure 49). The electricity infrastructure development in rural and urban areas and the penetration of electrical home appliances like air conditioners and televisions under growing income will induce electricity consumption growth.

Figure 49 Electricity consumption [Reference Scenario]



At the moment, OECD countries capture 48% of final electricity consumption. From 2013 to 2040, however, China (the world's largest electricity consumer) will further expand its consumption by 3,823 TWh, an amount which exceeds the present consumption of the second largest electricity consumer, the United States. India's electricity consumption will rise at an annual rate of 5.0%, reaching 3,283 TWh. Non-OECD countries will thus expand electricity consumption rapidly and substantially. About 80% of global electricity consumption growth in the outlook period will be generated in non-OECD countries. In several years from now, the non-OECD share of global electricity consumption will overwhelm the OECD share.

4. Energy supply

4.1 Crude oil

Supply

Table 5 shows a crude oil supply outlook in the *Reference Scenario.* In response to global oil demand growth, both OPEC and non-OPEC oil producing countries will expand crude oil supply. Their respective shares of global crude oil supply will remain almost unchanged between 2013 and 2020, standing at 40% for OPEC and 60% for non-OPEC oil producers. From 2030 to 2040, however, OPEC will gradually expand its share.

Through 2020, Iraq among the OPEC members will increase crude oil production. If Western countries lift economic sanctions on Iran in late 2015, Iran will also expand production. Among non-OPEC oil producers, North America will maintain a great presence with the expansion of shale and other oil production, which has slightly slackened on the crude oil price plunge since 2014. From 2020 through 2040, non-OPEC oil supply will continue increasing but at a much slower pace than OPEC. OPEC with abundant oil resources available for low-cost development will gradually grow dominant and the non-OPEC share of global oil supply will thus fall to 58% in 2030 and to 56% in 2040.

Table 5 Crude oil production [Reference Scenario]

(Mb/d)

	2013	2020	2030	2040	2013-2040
Total	88.77	95.42	106.00	114.20	+25.43
OPEC	36.63	37.82	44.80	50.40	+13.78
Middle East	26.84	27.45	33.10	38.00	+11.16
Others	9.79	10.37	11.70	12.40	+2.61
Non-OPEC	49.95	55.10	58.20	60.50	+10.56
North America	14.05	16.70	16.90	16.80	+2.75
Latin America	7.00	8.50	9.80	10.80	+3.80
Europe and Eurasia	17.16	17.40	18.50	19.85	+2.70
Middle East	1.36	1.45	1.55	1.60	+0.24
Africa	2.11	2.90	3.00	3.10	+0.99
Asia	8.28	8.15	8.45	8.35	+0.07
China	4.22	3.90	3.70	3.60	-0.62
Indonesia	0.88	0.90	0.90	0.85	-0.03
India	0.91	0.80	0.70	0.65	-0.26
Processing gains	2.20	2.50	3.00	3.30	+1.10

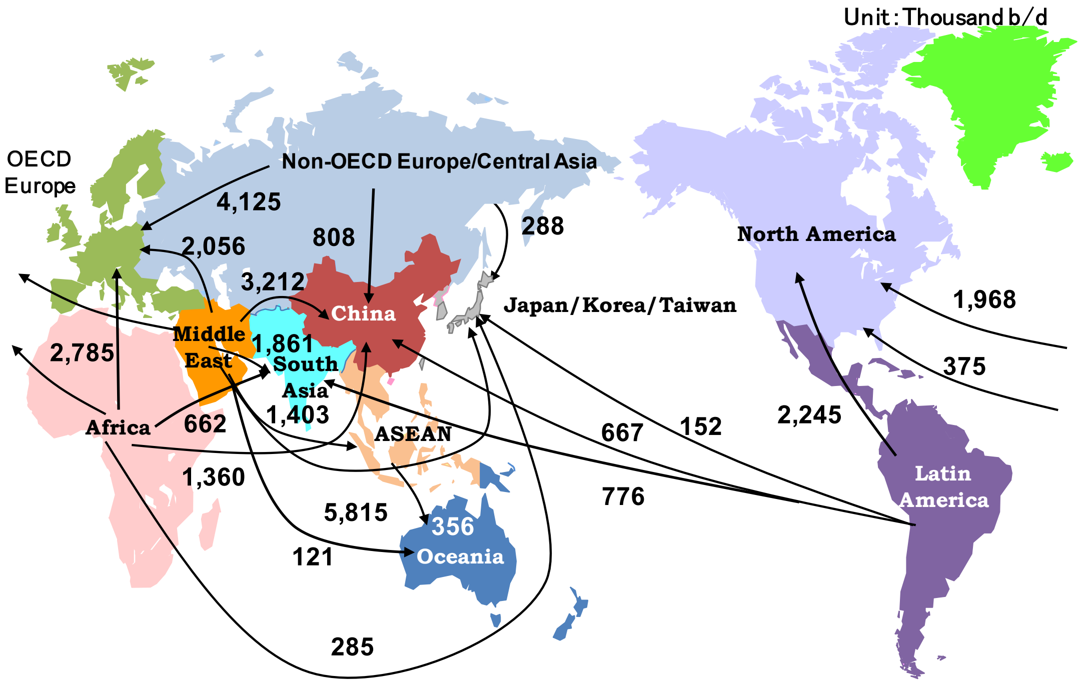
Trade

Figure 50 and Figure 51 indicate crude oil trade flows as of 2014 and 2030, respectively[9]. Global crude oil trade will increase by nearly 6 Mb/d from 38.8 Mb/d in 2014 to 44.6 Mb/d in

[9] We used a global trade model based on linear programming for analysing crude oil trade flows. We

2030 in line with global oil consumption growth. OECD countries including Western nations and Japan will reduce crude oil imports due to a structural demand fall through the improvement of vehicle fuel efficiency and falling population, as well as increasing domestic oil production in North America. But growth in imports by non-OECD countries with increasing oil demand will more than offset the decline in imports by OECD countries.

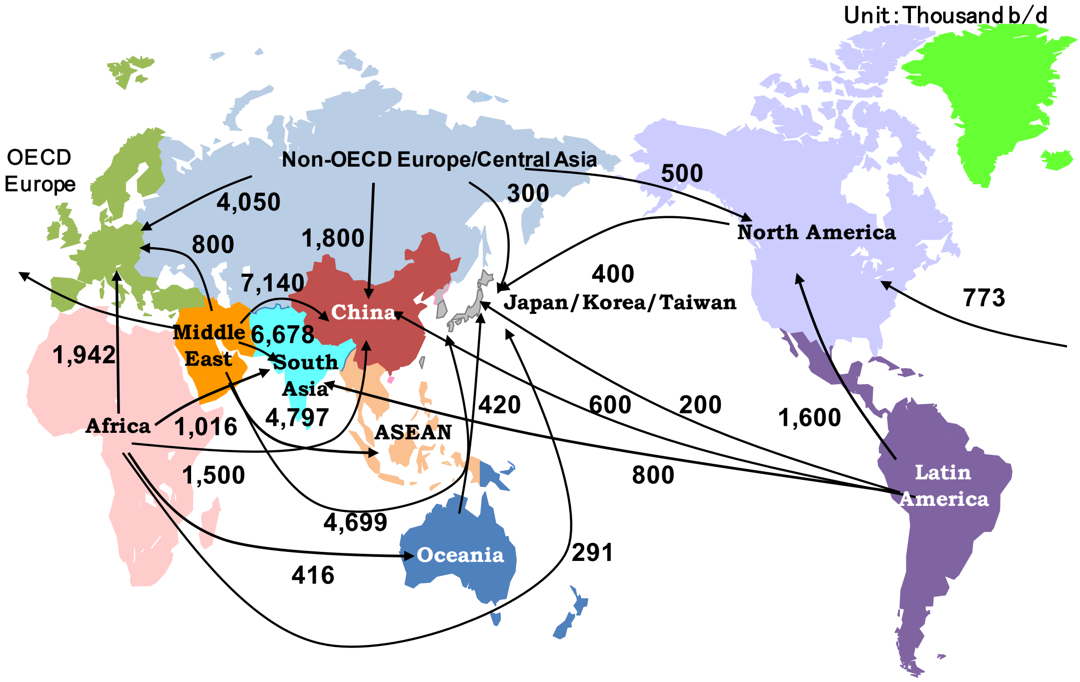
Figure 50 Major crude oil trade flows [2014]



Note: Does not include petroleum products
Source: BP (2015), DOE/EIA website, etc.

adopted energy production projections as well as product-by-product oil demand projections in each scenario as preconditions for the model calculations. We referred to the annual average crude oil prices and price gaps between crude oil brands in 2013 to make assumptions for 2030.The oil refining capacities in the future are assumed based on future growth in petroleum product demand (particularly middle distillate demand) in addition to published investment projects.

Figure 51 Major crude oil trade flows [Reference Scenario, 2030]



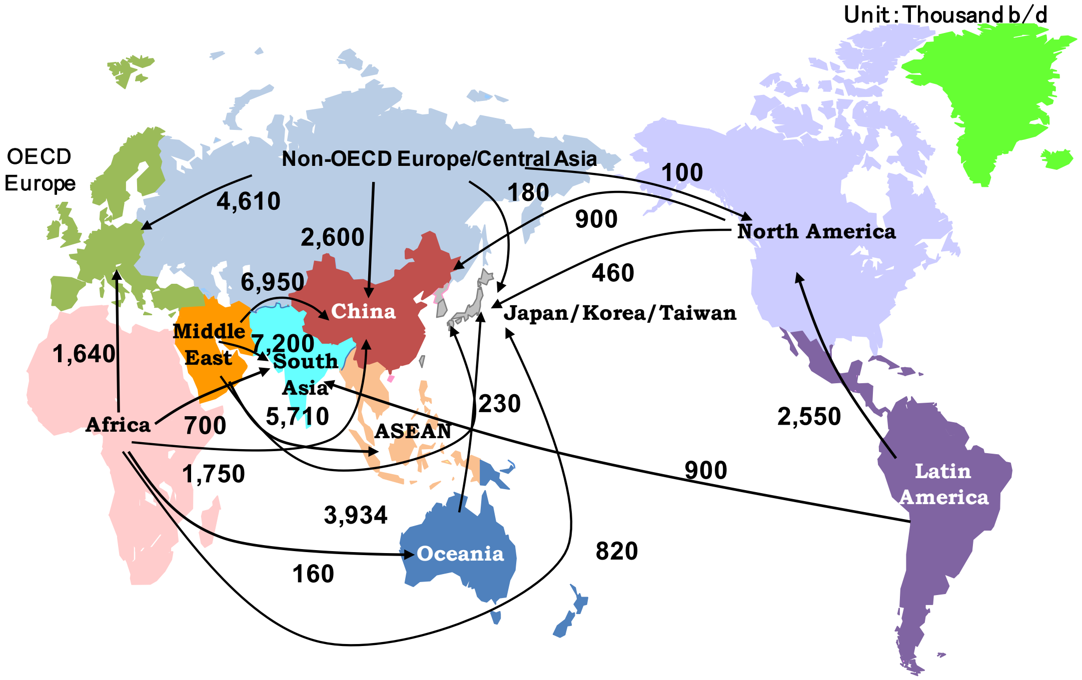
Note: Does not include petroleum products

North America will substantially reduce oil imports due to domestic production growth as noted above. Its imports from the Middle East will plunge from 1.9 Mb/d in 2014 to around 0.8 Mb/d in 2030 and Europe will see a similar trend. As domestic demand decreases with imports from Russia and Africa remaining unchanged, imports from the Middle East that cost more for transportation will halve from 2014 to 0.8 Mb/d in 2030. In such circumstances, the Middle East's exports to the Asian market will increase, accounting for more than 90% of its total exports. The Asian market will expand imports from Russia, Africa and Latin America as well as the Middle East, making progress in the diversification of oil supply sources. The United States is assumed to lift a ban on crude oil exports by 2030, exporting about 0.5 Mb/d to Northeast Asia.

Figure 52 indicates crude oil trade flows in 2040. The United States will reduce imports due to decline in domestic demand, while crude oil from Canada and Latin America will increase and boast more cost competitiveness. As a result, imports from these regions and domestic production will satisfy U.S. demand, eliminating the need to import from the Middle East while imports from Russia will decrease substantially. Europe will also reduce demand and overall imports, with imports from neighbouring Russia and Africa increasing their weight. The United States and Europe will make progress in the regionalisation of crude oil supply.

The Asian market in 2040 will still import most of its crude oil from the Middle East but it will begin to import from Canada as well as the United States. North America's supply to the Asian market will reach 1.5 Mb/d. Africa will increase crude oil exports to the Asian market in order to make up for the fall in European demand. Latin America will continue to export crude oil to the Asian market including China and India. Oil supply flows for the Asian market will thus be globalised or internationalised, unlike those for European and U.S. markets.

Figure 52 Major crude oil trade flows [Reference Scenario, 2040]



Note: Does not include petroleum products

4.2 Natural gas

Production

Through 2040, conventional and unconventional natural gas production in the world will increase to meet growing demand. Production in non-OECD Europe/Central Asia and the Middle East, both traditional producers of conventional natural gas, will expand production by 361 Bcm and 416 Bcm from 2013 to 1,272 Bcm and 979 Bcm, respectively, in 2040. North America will increase natural gas production in 2040 to 1,191 Bcm, becoming the world's second largest producer after non-OECD Europe/Central Asia. Spurred by a robust demand, Asia and Oceania will increase natural gas production at a higher pace than traditional conventional gas producers, posting 1,184 Bcm in natural gas production in 2040.

Shale gas production will gain momentum mainly in Canada, Argentina and China after 2025. As a result, unconventional natural gas will reach 27% of global natural gas production in 2040.

Table 6 Natural gas production [Reference Scenario]

(Bcm)

	2013	2020	2030	2040	2013-2040
Total	3,530	4,076	4,971	5,753	+2,223
Unconventional	394	608	1,070	1,543	+1,149
North America	849	998	1,107	1,191	+342
Unconventional	361	519	686	846	+485
Latin America	227	251	329	398	+171
Unconventional		5	109	187	+187
OECD Europe	265	257	243	232	-33
Unconventional		0	5	16	+16
Europe/Eurasia	911	966	1,139	1,272	+361
Russia	627	667	763	827	+200
Unconventional			23	38	+38
Middle East	563	618	858	979	+416
Unconventional			17	29	+29
Africa	206	241	369	497	+291
Unconventional		2	11	35	+35
Asia	441	590	736	986	+545
China	124	225	288	424	+300
Unconventional	25	41	101	204	+179
South Asia	90	117	178	249	+159
Unconventional		0	16	32	+32
Southeast Asia	222	245	267	311	+89
Unconventional		7	32	47	+47
Oceania	68	155	190	198	+130
Unconventional	8	34	70	109	+101

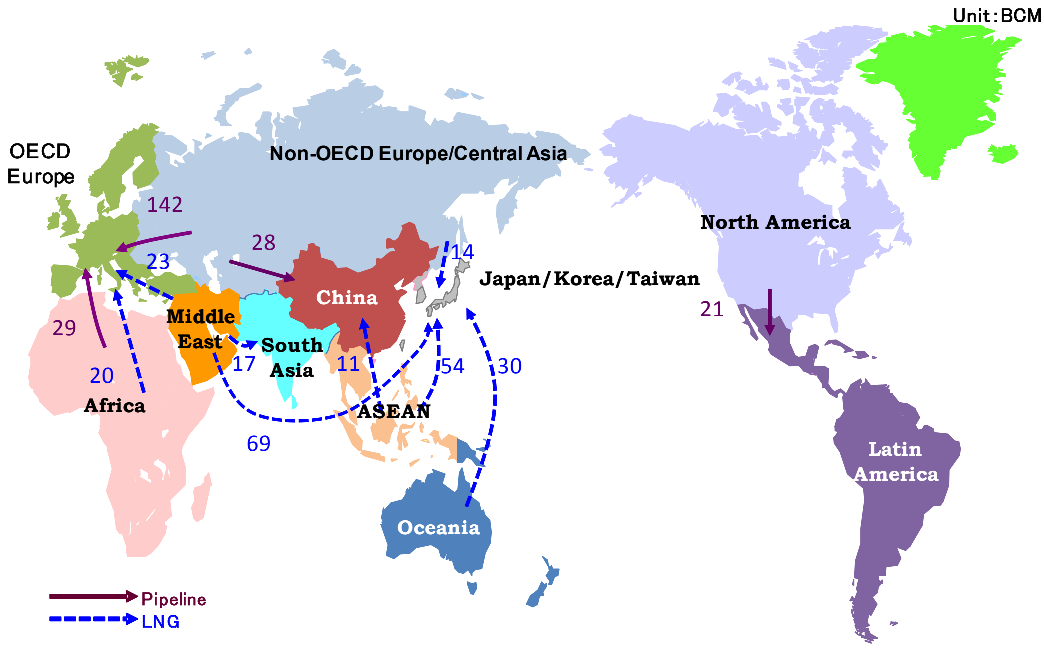
Trade

In 2013, 1,040 Bcm accounting for some 30% of global natural gas production was exported. Of the exports, interregional trade captured 450 Bcm. Major exporters for interregional trade were Russia and others in non-OECD Europe/Central Asia, and the Middle East. Among major importers were OECD Europe and Asia, including Japan, Korea and Chinese Taipei.

Major interregional natural gas trade flows in 2014 were pipeline gas exports from Russia and other non-OECD Europe/Central Asia countries to OECD Europe and LNG exports from Southeast Asia, Oceania and the Middle East to Japan, Korea and Chinese Taipei (Figure 53).

Natural gas trade will increase faster than consumption, with interregional trade growing to 1,000 Bcm in 2030 and around 1,200 Bcm in 2040. Regions expanding exports dramatically will include non-OECD Europe/Central Asia, as well as North America and Oceania where unconventional natural gas production will grow. Net exports from non-OECD Europe/Central Asia in 2040 will increase to 494 Bcm, driven by Russian export growth. Net exports from North America will reach 160 Bcm rivalling 154 Bcm from Oceania. Net imports in 2040 will rapidly increase to 282 Bcm in China and 151 Bcm in South Asia including India.

Figure 53 Major natural gas trade flows [2014]



Asia will become a major market for net export growth in North America, Oceania and non-OECD Europe/Central Asia. North America will rapidly expand exports as the United States becomes a net exporter by 2020 and Canada's LNG exports gain momentum in the 2020s. In 2030, North America will export 42 Bcm to Japan, Korea and Chinese Taipei and 16 Bcm to Europe, rising as a major LNG exporting region. To meet growing Chinese demand, non-OECD Europe/Central Asia will rapidly expand pipeline gas supply to 109 Bcm in 2030. LNG supply mainly from Oceania and the Middle East will also contribute to satisfying Chinese demand. Supply from non-OECD Europe/Central Asia to OECD Europe, which is now trending down, will recover moderately due to a decline in production in non-OECD Europe and the construction of pipelines via Turkey.

The basic trend of natural gas flows will continue through 2040. North America will further expand LNG exports, supplying 55 Bcm to Japan, Korea and Chinese Taipei and 19 Bcm to Europe in 2040. Non-OECD Europe/Central Asia will increase pipeline gas supply to China to 148 Bcm, enhancing a shift to the Asian market. Oceania, which also has great export potential, will increase LNG exports mainly to Asia, supplying 48 Bcm to Japan, Korea and Chinese Taipei and 31 Bcm to China.

Figure 54 Major natural gas trade flows [Reference Scenario, 2030]

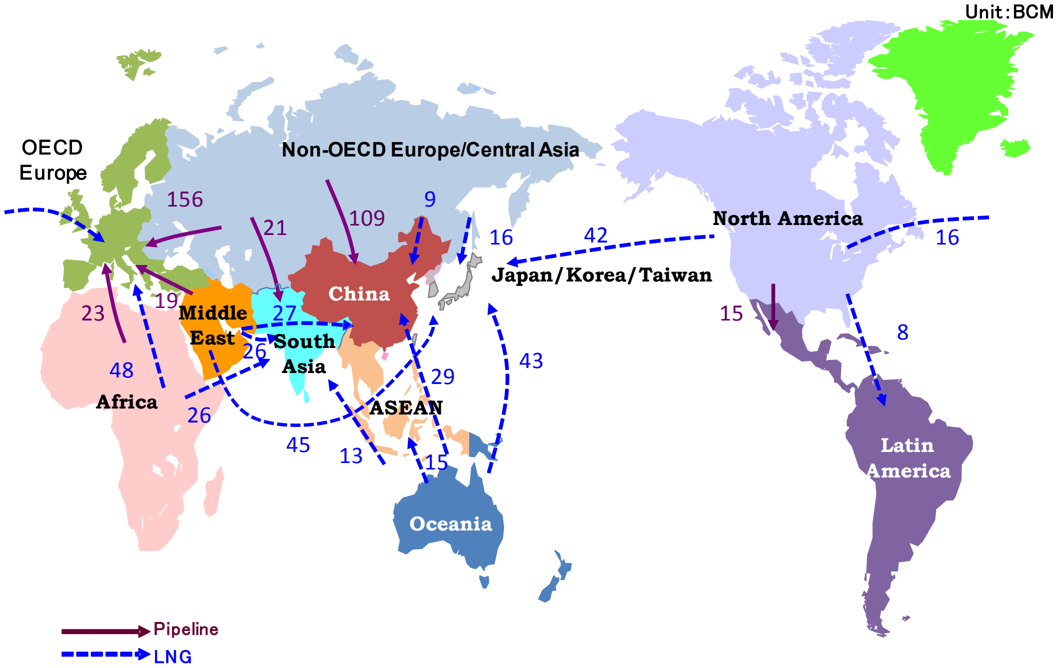
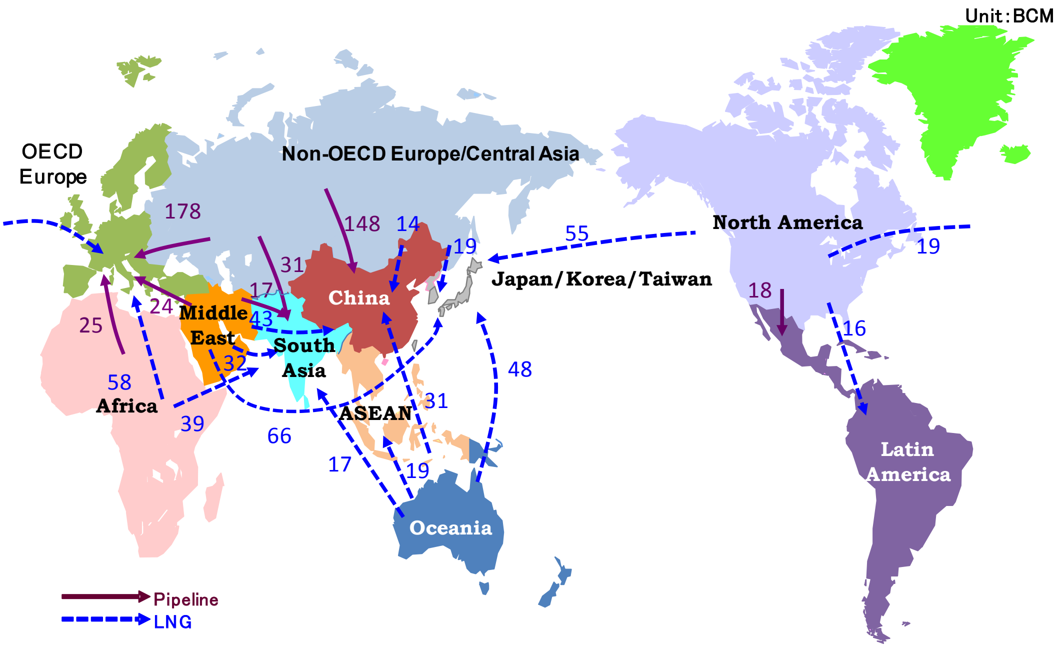


Figure 55 Major natural gas trade flows [Reference Scenario, 2040]

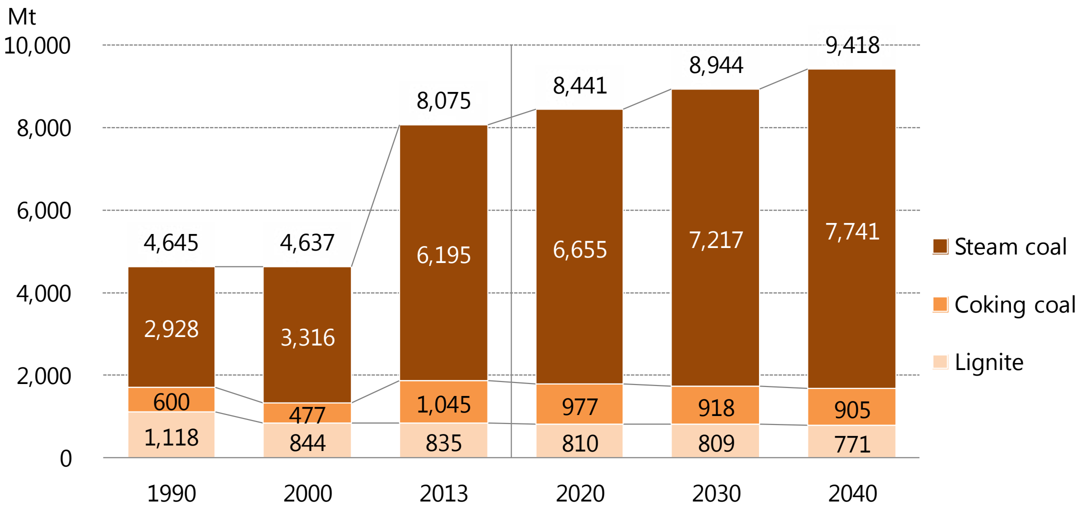


4.3 Coal

Production

Global coal production will increase from 8,075 Mt in 2013 to 9,418 Mt in 2040 as coal demand expands mainly in Asia (Figure 56). Steam coal production will rise 1.25-fold from 6,195 Mt in 2013 to 7,741 Mt in 2040, while coking coal production will decrease from 1,045 Mt in 2013 to 905 Mt in 2040 and lignite production from 835 Mt in 2013 to 771 Mt in 2040.

Figure 56 Coal production by type [Reference Scenario]



By region, coal production will increase in Asia with growing coal demand and in Oceania, Africa and Latin America with major coal exporting countries. But it will decrease in North America and OECD Europe where coal demand will decline (Figure 57). Table 7 indicates steam coal production by region and Table 8 coking coal production by region.

Asian coal production will grow by 1,118 Mt from 5,080 Mt in 2013 to 6,198 Mt in 2040. In China, the world's largest coal consumer, producer and importer, domestic coal production has slackened after expanding rapidly to meet demand growth. As steam coal demand increases in line with electricity demand growth, coal production will rise moderately before almost leveling off after 2030. Meanwhile, coking coal production will trend down as demand falls in line with a decline in crude steel production. As a result, the growth in Chinese coal production (a combination of steam and coking coal production) will gradually decelerate, peaking around 2030. India, with its abundant coal resources high in ash content, will increase steam and coking coal production in conjunction with demand growth. As coal mining development and transport infrastructure construction have in the past failed to catch up with demand growth, India may fail in the future to cover its growing demand with domestic production. Indonesia had so far substantially increased steam coal production in line with the expansion of the Asian market. At present, however, production has decreased on a fall in Chinese imports and slack in coal prices. In the future, Indonesia is expected to increase coal production in line with domestic demand growth but the growth may be limited as the Indonesian government plans to sustainably and efficiently use domestic coal resources for the benefit of its people under its new mining law and restrict production.

North American coal production will decrease from 973 Mt in 2013 to 665 Mt in 2040. U.S. production will decline due to a domestic demand fall, production cost hikes and environmental problems involving coal mining. Steam coal production will fall substantially from 756 Mt in 2013 to 500 Mt in 2040 on a domestic demand drop under environmental regulations, although demand for exports to such regions as Latin America, Africa and Asia is expected to increase. In Canada as well, steam coal production will drop in line with a domestic demand decline.

In OECD Europe, coal production will fall from 533 Mt in 2013 to 450 Mt in 2040 due to a regional decline, production cost hikes and the elimination of subsidies for the coal industry in some countries. Both steam and coking coal production will decline.

In non-OECD Europe, coal production will almost level off as demand for exports increases despite a decline in regional demand. Russia will increase both steam and coking coal production as the Asian market expands despite the shrinkage of the European market.

In Africa, coal production will rise from 268 Mt in 2013 to 424 Mt in 2040 in line with growth in regional steam coal demand and in export demand (including Asian steam coal demand and Indian coking coal demand). In South Africa, steam coal production will increase. Mozambique will expand both coking and steam coal production.

Latin America will increase coal production due to expanding regional and export demand. Steam coal exporter Columbia will increase production on the expansion of the Asian market while its major export destination, the European market, will shrink. Exports to Africa, South America and the Middle East will increase.

In Oceania, Australia will substantially raise coal production in line with the expansion of the coal market including Asia. Australian steam coal production in 2040 will increase 2.6-fold from 2013 to meet growing exports to Asia and make up for a decline in steam coal exports from Indonesia.

Figure 57 Coal production by region [Reference Scenario]

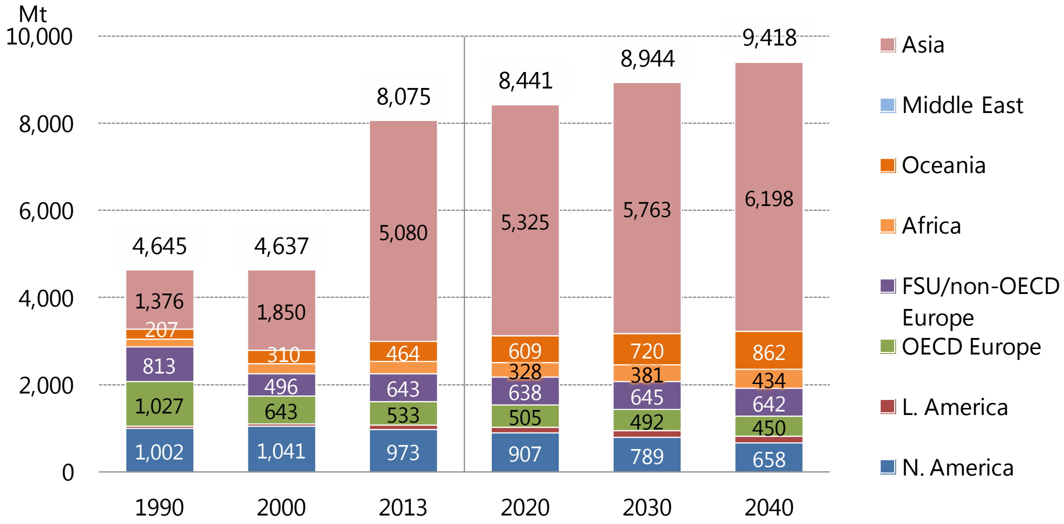


Table 7 Steam coal production [Reference Scenario]

(Mt)

	2013	2020	2030	2040	2013-2040
World	6,195	6,655	7,217	7,741	+1,546
North America	782	741	634	511	-270
United States	756	720	617	499	-256
Latin America	104	121	143	160	+56
Columbia	81	93	112	128	+47
OECD Europe	94	95	87	79	-15
FSU/non-OECD Europe	335	341	356	374	+39
Russia	179	195	217	226	+47
Middle East	0	0	0	0	0
Africa	261	314	362	407	+146
South Africa	253	299	337	371	+118
Asia	4,381	4,661	5,149	5,588	+1,207
China	3,282	3,484	3,656	3,666	+384
India	516	653	902	1,250	+734
Indonesia	484	421	461	504	+20
Oceania	239	381	486	621	+383
Australia	237	380	484	620	+383

Table 8 Coking coal production [Reference Scenario]

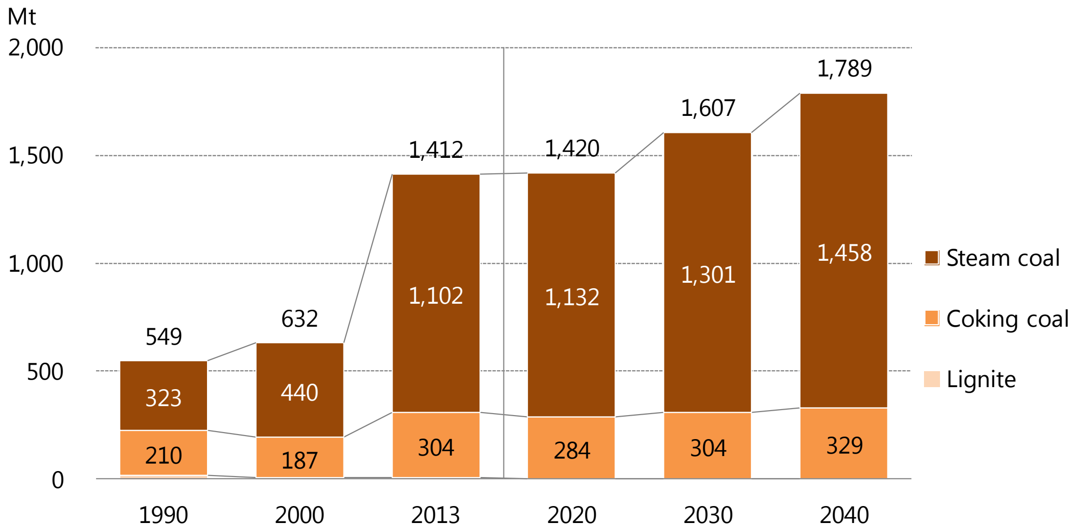
(Mt)

	2013	2020	2030	2040	2013-2040
World	1,045	977	918	905	-140
North America	112	94	98	102	-10
United States	78	68	70	73	-5
Latin America	5	4	5	5	+0
Columbia	4	4	4	5	+1
OECD Europe	22	19	15	13	-10
FSU/non-OECD Europe	106	102	104	105	-1
Russia	74	66	69	71	-3
Middle East	1	1	1	1	0
Africa	7	13	19	26	+19
Mozambique	3	9	15	22	+19
Asia	629	579	504	469	-161
China	562	502	413	356	-205
India	50	60	72	91	+42
Mongolia	15	13	13	13	-2
Oceania	162	164	172	183	+22
Australia	159	162	171	182	+22

Trade

Coal trade will expand 1.3-fold from 1,412 Mt in 2013 to 1,789 Mt in 2040 in line with demand growth. Steam coal trade will increase 1.3-fold from 1,102 Mt in 2013 to 1,458 Mt in 2040 in response to demand growth in India and Southeast Asia. Coking coal trade will grow 1.1-fold from 304 Mt in 2013 to 329 Mt in 2040 (Figure 58).

Figure 58 Coal trade by type [Reference Scenario]



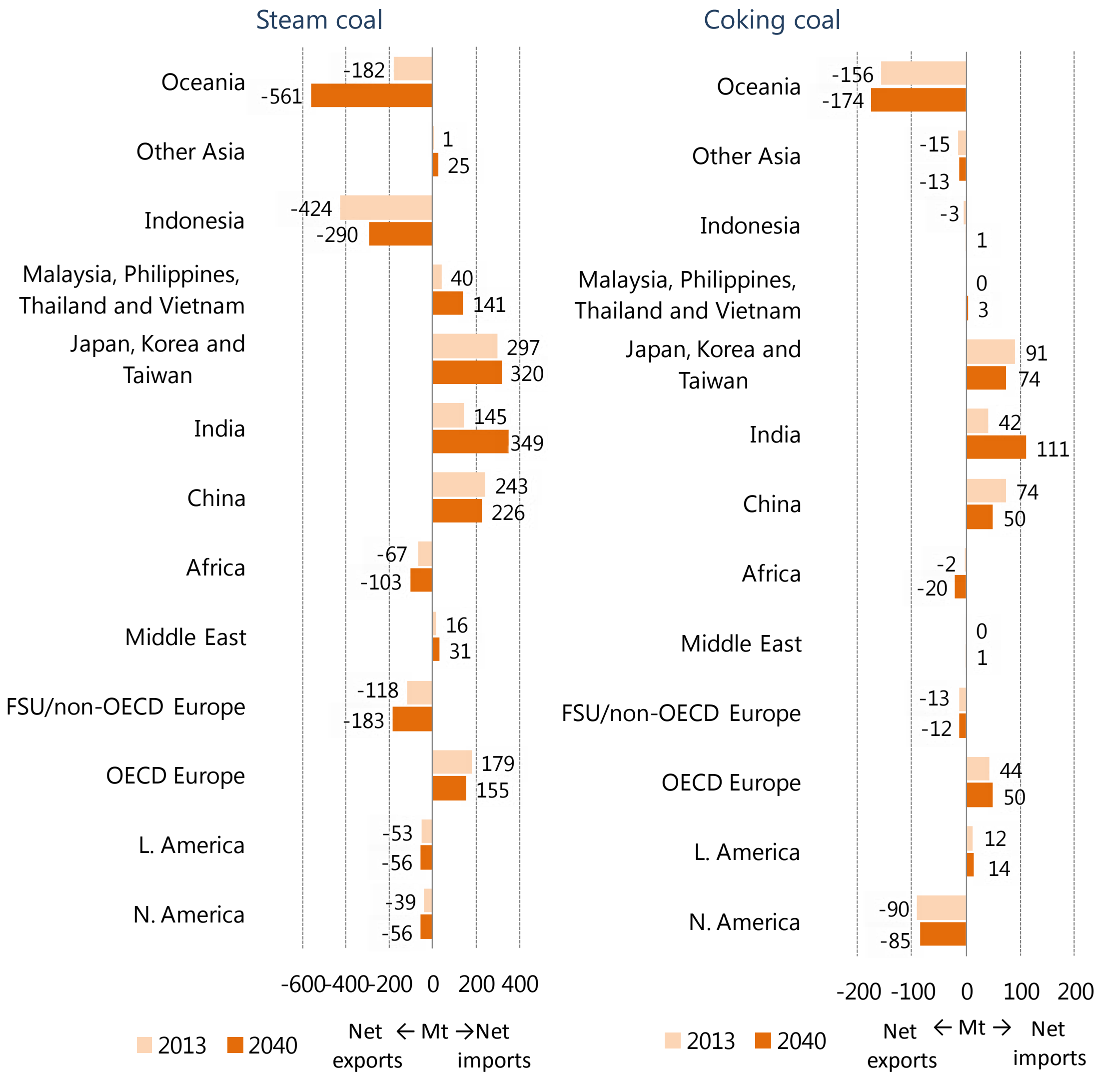
Steam coal imports in Asia will increase from 773 Mt in 2013 to 1,098 Mt in 2040 in response to growing demand for coal for power generation. India and Southeast Asia (covering Malaysia, Thailand, the Philippines and Vietnam) will substantially expand imports. Of the 326 Mt increase in Asian steam coal imports, India will account for 204 Mt and Southeast Asia for 91 Mt. Between 2013 and 2040, steam coal imports will expand by 43 Mt in Latin America, by 15 Mt in the Middle East and by 13 Mt in Africa, while OECD Europe and China will reduce imports. OECD Europe will post a decline due to a demand fall. Chinese imports, though expected to increase in conjunction with domestic demand growth, decreased substantially in 2014 and remained slack in 2015, resulting in the decline from 2013.

Steam coal exports from Australia, South Africa, Russia and Colombia will increase. On the other hand, Indonesia will substantially reduce exports as production is restricted despite domestic demand growth. Australia will expand steam coal exports from 182 Mt in 2013 to 561 Mt in 2040 in accordance with the expansion of the Asian market. South Africa will boost exports from 74 Mt in 2013 to 122 Mt in 2040, Russia from 117 Mt to 176 Mt and Colombia from 79 Mt to 125 Mt.

Coking coal imports will rise from 42 Mt in 2013 to 111 Mt in 2040 for India, while falling for China (down 24 Mt) and Japan (16 Mt) where demand will decline. OECD Europe will slightly increase imports due to a regional production fall despite a demand drop.

Coking coal exports will increase in Australia as well as in Mozambique currently developing its coal resources. Exports will slightly fall in Canada and the United States as China and Japan reduce imports. Exports will also decline in Mongolia due to a drop in China's imports. Exports from Australia will increase from 154 Mt in 2013 to 172 Mt in 2040 and those from Mozambique from 3 Mt to 21 Mt. In contrast, the U.S. exports will fall from 60 Mt in 2013 to 57 Mt in 2040, Canadian exports from 35 Mt to 33 Mt, Mongolian exports from 15 Mt to 13 Mt and Russian exports from 22 Mt to 20 Mt.

Figure 59 Net coal imports by region [Reference Scenario]

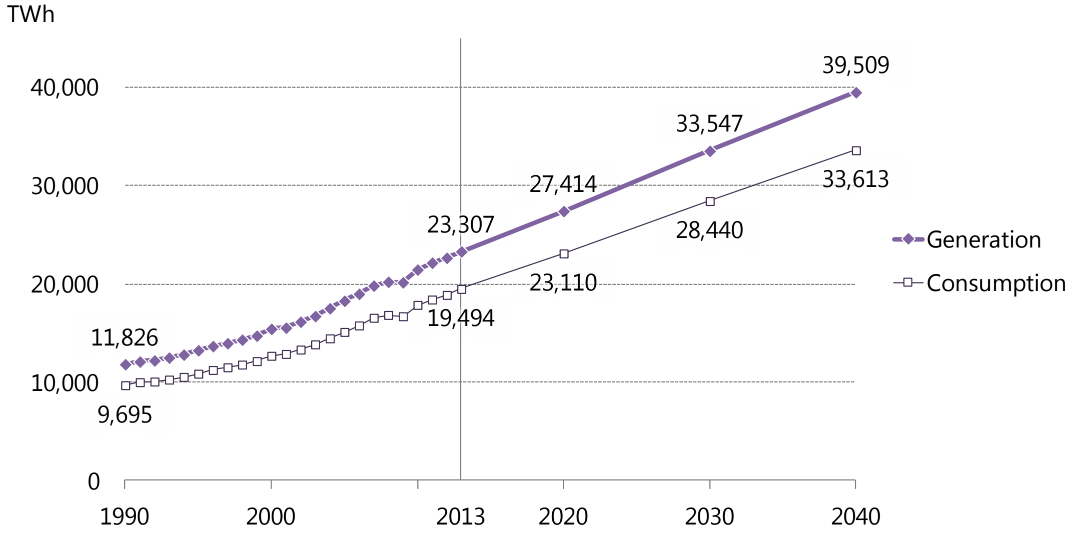


4.4 Electricity generation

Electricity generation and its mix

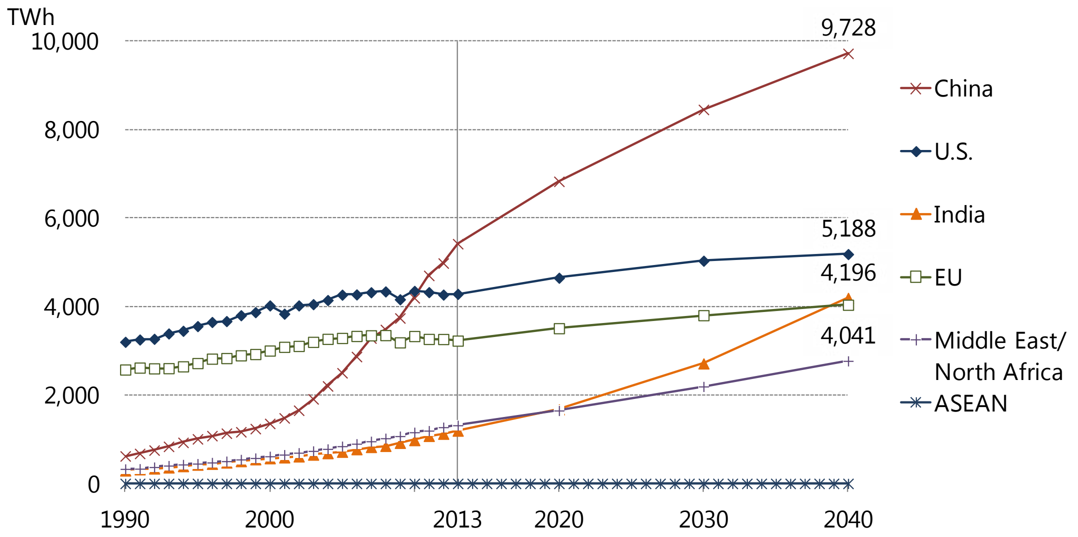
In line with electricity demand growth, global electricity generation will increase 1.7-fold from 23,307 terawatt-hours (TWh) in 2013 to 39,509 TWh in 2040 (Figure 60). The increase of 16,202 TWh is 16 times as large as Japan's electricity generation in 2013 and three times as large as China's generation.

Figure 60 Global power generation and consumption [Reference Scenario]



Non-OECD countries will account for more than 80% of the electricity generation growth through 2040 (Figure 61). Asian electricity generation, driven by China, India and ASEAN, will increase at an annual rate of 2.7% from 9,481 TWh in 2013 to 19,519 TWh in 2040. . Generation growth in China between 2013 and 2040 will reach 4,305 TWh.

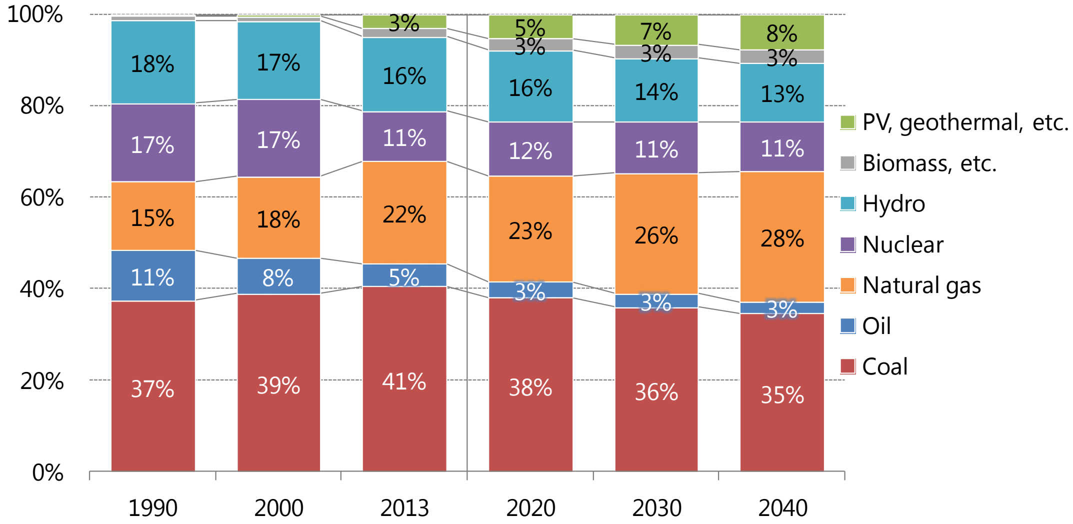
Figure 61 Power generation by region [Reference Scenario]



Coal accounted for the largest share of global electricity generation in 2013 at 41%, followed by 22% for natural gas, 16% for hydro and 11% for nuclear (Figure 62). Through 2040, coal will retain the largest share, continuing to serve as a mainstay electricity source. As technological development allows combined cycle gas turbines (CCGTs) to diffuse, with gas turbines used to adjust for variable renewable energy generation, a shift to natural gas for power generation will make progress. The share for natural gas will thus expand from 22% in

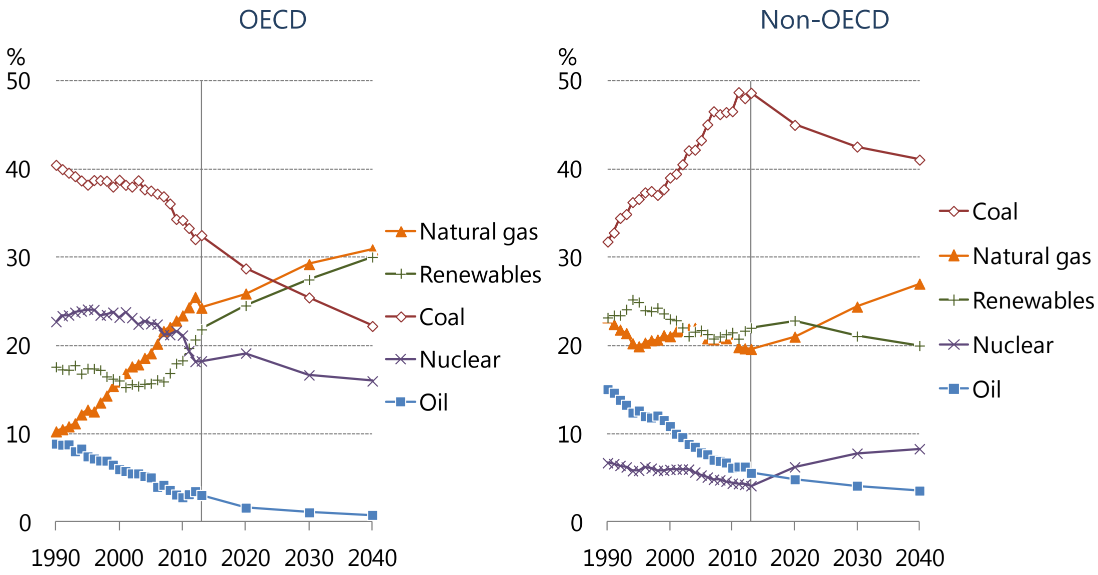
2013 to 28% in 2040. The share for oil will trend down in OECD countries as well as in the oil-rich Middle East. Nuclear plant construction will make progress mainly in Asia as a measure to ensure energy security and prevent climate change. But nuclear power generation growth will fail to exceed electricity demand growth through 2040. Nuclear energy's share of electricity generation will thus level off from 2013 to 2040 at 11%. Wind power, solar photovoltaic and other renewable energy generation will expand at an unrivaled annual rate of 5.5% on the strength of policy support and cost reduction. But renewable energy's share of electricity generation will still be limited to less than 10% in 2040.

Figure 62 Global power generation mix [Reference Scenario]



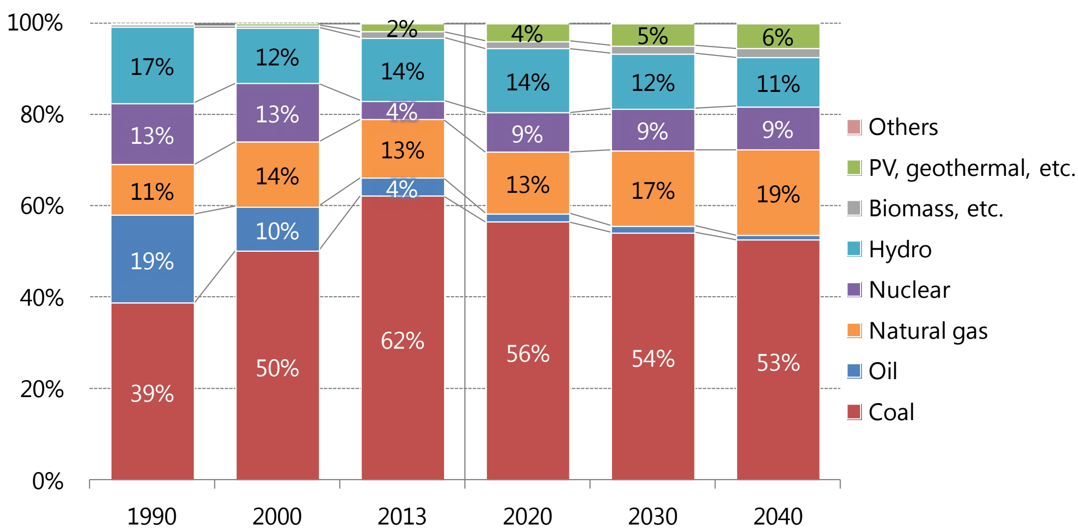
In OECD countries, renewable energy's share of total electricity generation in 2040 will rise to 30%, rivalling the natural gas share. The renewable energy share in 2040 will be the second largest after natural gas.

Figure 63 Power generation mix for OECD and non-OECD [Reference Scenario]



In Asia including China and India, coal will remain a mainstay electricity source in response to the rapid electricity demand growth (Figure 64). ASEAN has made a great shift from oil to natural gas as electricity generation fuel since the 1990s due to natural gas development in the Bay of Thailand and other locations. Since natural gas production peaked out and gas demand emerged in other sectors than electricity generation in the 2000s, however, natural gas supply capacity for electricity generation has become short. As demand for natural gas for electricity generation is growing, ASEAN countries as well as China and India are planning to import natural gas. As coal's share of electricity generation decreases while still high, natural gas's share will increase from 13% to 19%.

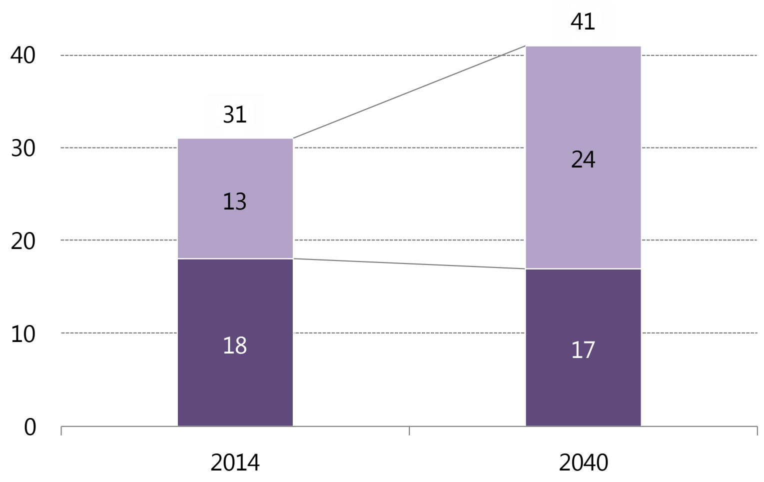
Figure 64 Asian power generation mix [Reference Scenario]



Nuclear

The number of nuclear generating countries will expand from 31 in 2014 to 41 in 2040 (Figure 65). The number of nuclear generating OECD countries will fall from 18 in 2014 to 17 in 2040, while the number will rise from 13 to 24 during the same period in non-OECD countries that need large amounts of electricity to support their economic growth.

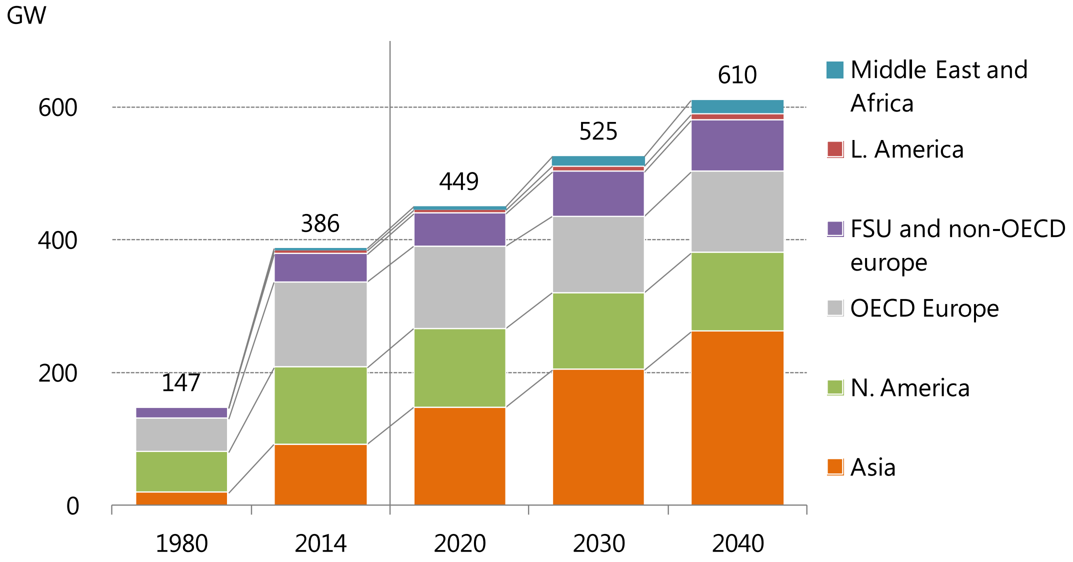
Figure 65 Number of countries with commercial nuclear power plants [Reference Scenario]



The Fukushima Daiichi nuclear power plant accident has directly affected nuclear energy policies in Japan and some European countries. The United States, France, Russia and Korea continue to proactively promote nuclear power generation. Emerging countries like China have not changed their respective nuclear promotion policies aimed at securing stable energy supply, preventing global warming, and maintaining and enhancing international competitiveness through their nuclear industry development. As explained later, France has passed an energy transition law to limit nuclear generation capacity to the present level of 63 GW and increase renewable energy's share of final energy consumption to 32% by 2030. France made no change to its policy of maintaining nuclear generation as a mainstay electricity source.

In the United States, the world's largest nuclear generating country with 99 nuclear reactors, new nuclear plant construction has slowed down as the economic advantages of its fossil energy resources have increased thanks to shale gas and oil development. The country is even shutting down some existing reactors for economic reasons. Given fuel price fluctuation risks accompanying a shift from nuclear energy to natural gas, as well as climate change implications, however, the United States will retain the policy of maintaining nuclear power plants. Installed capacity for nuclear power generation declined to 103 GW in 2014 and will rise back to 108 GW in 2040 as new reactors under construction launch operation (Figure 66).

Figure 66 Nuclear power generating capacity by region [Reference Scenario]



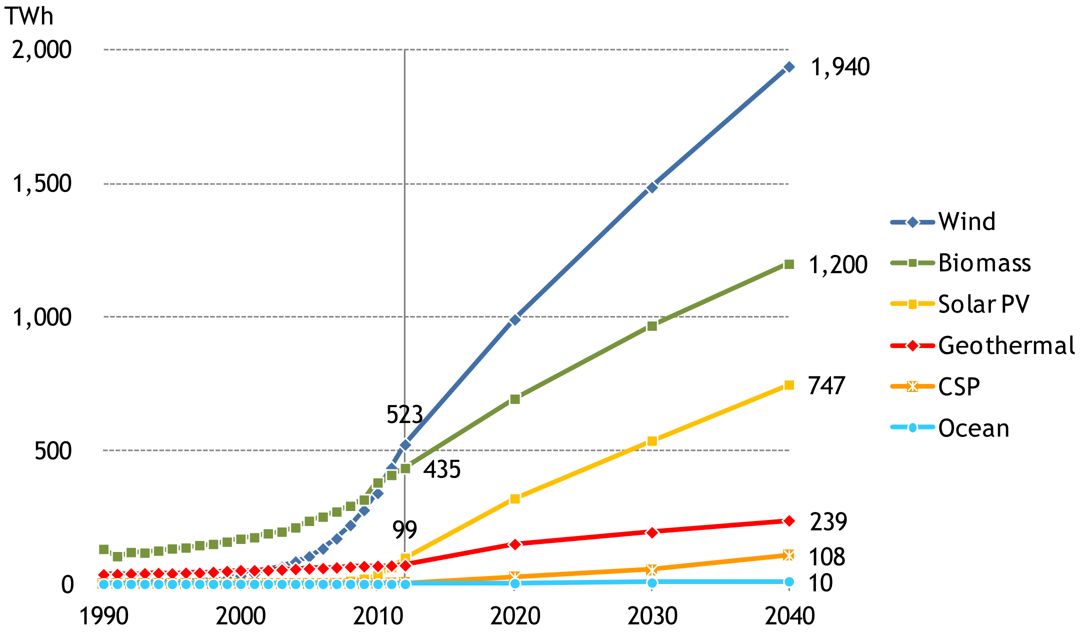
In France known as the largest nuclear energy promoter in Europe, an energy transition law was enacted in July 2015 to reduce nuclear energy's share of electricity generation to 50% by 2025. But France has faced electricity rate hikes and employment problems and only released a plan to shut down the Fessenheim Unit 1 reactor. The present situation, including installed nuclear generation capacity at 66 GW as of 2014, will be maintained for the immediate future. Germany, Switzerland and Belgium have made clear their nuclear phase-out plans in response to the Fukushima accident and will eliminate nuclear generation from 2025 to 2035. While outdated nuclear reactors are being decommissioned in European OECD countries, their moves to construct new reactors are also seen. Therefore, Europe's installed nuclear generation capacity will fall to 115 GW temporarily in 2030 and rise back later. Russia has vowed to proactively use nuclear energy at home and abroad and its installed nuclear generation capacity in 2040 will more than double from the level of 25 GW for 2014 to 53 GW.

The presence of Asia including China and India will increase more and more in nuclear power generation. China will boost its installed nuclear generation capacity from 15 GW in 2014 to 112 GW in 2035, replacing the United States as the largest nuclear power generator in the world. Asian installed nuclear generation capacity will reach 261 GW in 2040, surpassing the combined OECD Europe and U.S. capacity of 244 GW. The United Arab Emirates and Saudi Arabia will lead the Middle East to raise installed nuclear generation capacity to 11 GW in 2025. South Africa and Brazil are planning to introduce nuclear generation and will steadily construct nuclear plants.

Renewables

Great expectations are placed on renewable energy including solar and wind energy. Renewable energy, particularly renewable energy power generation, has seen strong growth despite negative factors such as the unstable world economy, the reduction of subsidies, and crude oil price plunges. But non-hydro renewable energy-based electricity generation, which costs more and is intermittent depending on natural conditions (for solar photovoltaic and wind), will fall short of becoming a mainstay electricity source rivaling fossil resources on a global scale (Figure 67).

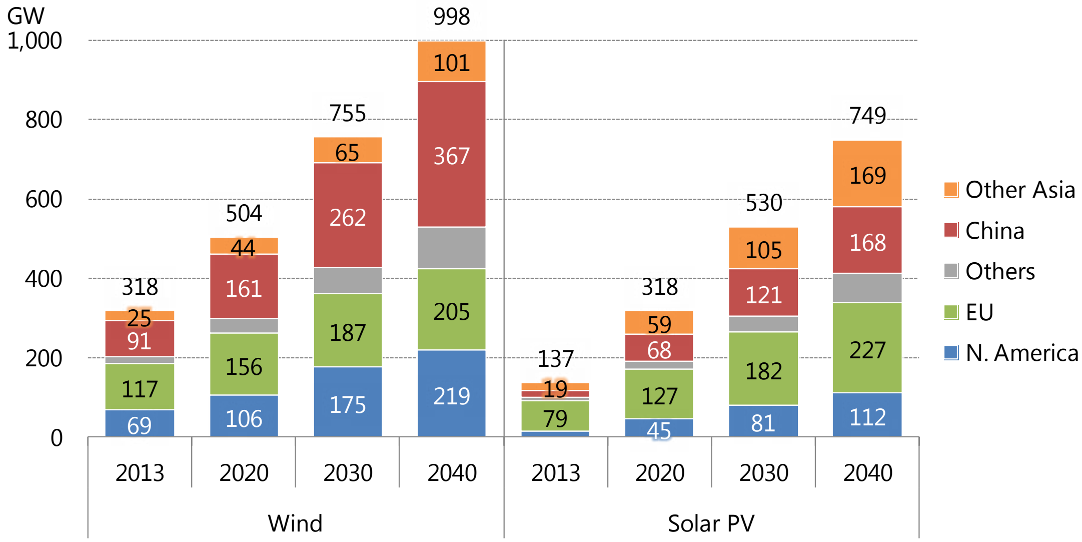
Figure 67 Global renewable energy power generation except hydro [Reference Scenario]



Renewable energy penetration may contribute to expanding low-carbon electricity sources, reducing dependence on energy imports, and potentially holding down fossil fuel prices. Large-scale renewable energy penetration will depend on cost reduction, improved efficiency, and harmonisation of renewable energy with energy systems through continuous research and development.

Although Europe and North America are still major wind power generation markets, Asia has become the world's largest wind power generation market, driven by China and India. In recent years, investment has increased in emerging wind power generation markets like Latin America and Africa. Installed wind electricity generation capacity is projected to more than triple from 318 GW in 2013 to 998 GW in 2040.

Figure 68 Wind and solar PV power generating capacity by region [Reference Scenario]



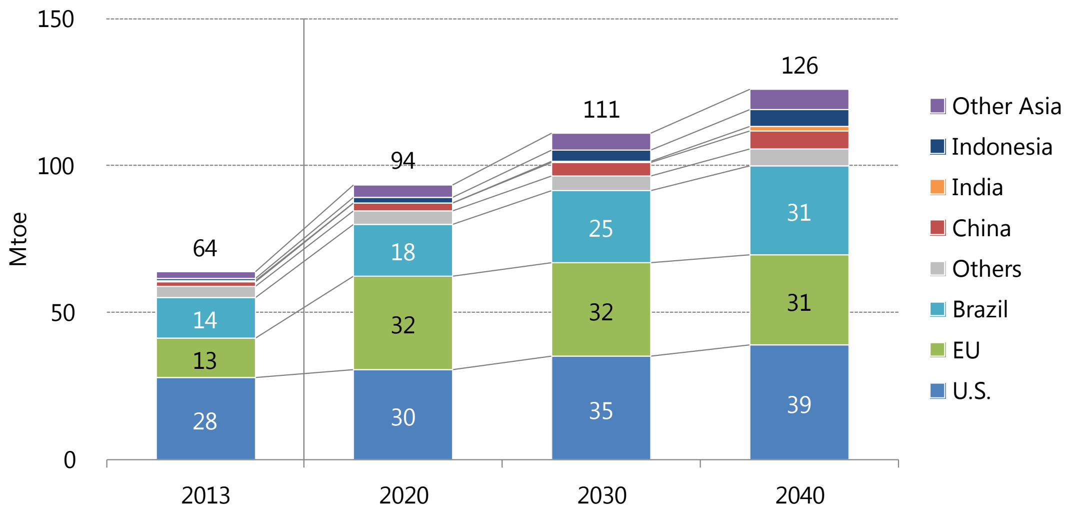
The global solar photovoltaic market will continue expanding as the Asia Pacific region including Japan, China and the United States replaces Europe as market leader. High government targets and enhanced incentives are major market drivers. For example, India's Narendra Modi administration has put forward an ambitious solar energy promotion target since its inauguration in 2014. Market expansion and technological development will gradually lower solar photovoltaics costs, contributing to spreading solar energy. Solar photovoltaic, while still having economic efficiency problems, is seen as a useful electricity source for remote areas where electricity infrastructure has yet to be developed. In the *Reference Scenario*, installed solar photovoltaic generation capacity in the world is expected to expand 5.5-fold from 137 GW in 2013 to 749 GW in 2040.

4.5 Biofuels

The penetration of liquid biofuels including bioethanol and biodiesel has made progress as part of measures on climate change, energy security and agriculture promotion. But biofuel consumption remains concentrated in the United States, Brazil and the European Union, which accounted for more than 85% of biofuel consumption in 2013.

Global biofuel consumption will increase from 64 Mtoe in 2013 to 126 Mtoe in 2040 (Figure 69). In the future, biofuel consumption will continue to be concentrated in the United States, Brazil and the European Union. In the United States, biofuel consumption will slightly increase on the penetration of vehicles that can run on fuels with high blend rate of bioethanol. In Brazil, biofuel consumption will continuously expand thanks to the spread of flexible fuel vehicles that can use both ethanol and gasoline. In the European Union, biofuel consumption will slightly decrease after 2025 as liquid fuel demand growth decelerates and concerns over first-generation biofuels' environmental impact grow. Asian developing countries including China, India, and Indonesia are expected to see significant biofuel consumption growth as liquid fuel demand increases. But their biofuel consumption will fall short of rivaling European, U.S. or Brazilian levels.

Figure 69 Biofuel consumption [Reference Scenario]



Part III

Exploring other paths through scenario analysis such as: Advanced Technologies and Lower Price

5. Potential and effects of introducing energy conservation and decarbonisation technologies

5.1 Present energy conservation

Energy conservation is important for energy security, for cutting costs and for climate change prevention. It is significant not only for energy consuming countries, but also for energy supplying countries as a means to maintain surplus export capacity. Energy conservation potential in 2040 in the *Advanced Technologies Scenario* will total 1,678 Mtoe, making the greatest contribution among climate change measures.

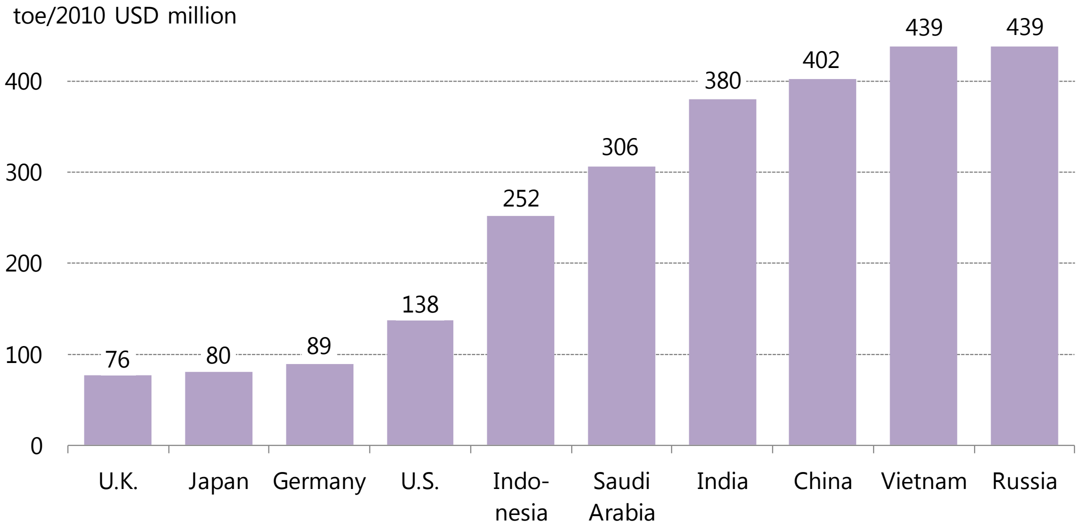
Table 9 indicates the introduction of energy conservation measures and policies, and the current emission intensity (CO_2 emissions per GDP) for major countries. While all of these countries have introduced a variety of energy conservation measures, their emission intensity data differs widely (Figure 70). This is because the energy conservation coverage, levels and degrees differ from country to country depending on industrial structure, weather, culture, population and economic development conditions. For example, the years for the introduction of some energy conservation laws differ from country to country. Similarly, the years for the introduction and coverage (including the range of products subject to energy conservation labelling) and degrees (including energy consumption standards) of conservation are different. Some countries introduced energy conservation policies without monitoring, verification or any other follow-up measures, leaving these policies ineffective. Despite the introduction of many energy conservation policies, therefore, there exists great energy conservation potential, with future efforts remaining important.

Table 9 Energy saving policies in selected countries

	Energy saving law	Energy saving targets	Energy saving diagnosis	Efficiency standards	Labelling system	Subsidies	Energy manager system	Energy intensity in 2013*
Japan	◎(1979)	◎	○	◎	◎	◎	◎	80
United States	◎(1975)	◎	○	◎	◎	◎	○	138
United Kingdom	○	◎	○	◎	◎	◎	○	76
Germany	○(1976)	◎	◎	◎	◎	◎	—	89
China	◎(1975)	◎	◎	◎	◎	◎	◎	402
India	◎(1975)	◎	○	○	◎	○	◎	380
Indonesia	○(2007)	◎	◎	○	◎	◎	◎	252
Vietnam	◎(2003)	◎	○	◎	◎	◎	◎	439
Saudi Arabia	△	◎	○	◎	◎	—	△	306

◎: Exist, ○: Exist but limited, △: Planned or considering, —: None. * toe/$2010 million

Figure 70 Energy intensity for selected countries [2013]



Note: Total primary energy consumption per unit of real GDP

5.2 Five major energy conservation principles

There are five major principles for promoting energy conservation.

Figure 71 Five major energy conservation principles

(1) Understanding	Significance / Direct and indirect effects of energy saving (Health, environment, etc.)
(2) Checking	Consumption / Energy saving efficiencies
(3) Action	Implementation / Introduction / Purchasing
(4) Improvement	Products / Technologies (Appliances, vehicles, buildings, etc.)
(5) Innovation	Integration / Systematization / Automation

(1) The first principle is to understand and be aware of the significance and importance of the effects and co-benefits of energy conservation. Measures to promote awareness include education (at schools, communities, workplaces, etc.), public relations activities (energy conservation campaigns and energy-saving events) and international cooperation (information sharing on technologies and policies). Events such as the Oil crises and the Great East Japan Earthquake have been important for citizens to recognize the importance of energy conservation in Japan.

(2) The second important principle is to visualize the performance of the current equipment through quantifying energy consumption. Means to check consumption include the provision of information through energy monitors, and power and gas utility bills to

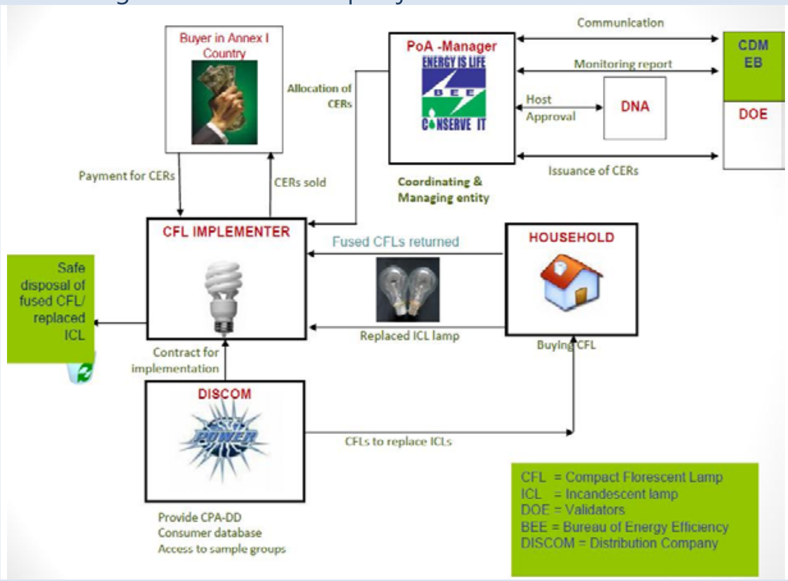
visualize consumption. Metering energy consumption allows for the selection of effective measures which can be identified through diagnoses (for example, by energy service companies) of energy conservation potential in uses and performance of equipment, reviews of operations by energy managers at companies, and the development of statistical energy data.

(3) The third principle is to implement energy conservation measures, including the introduction of high-performance equipment. Means to promote such actions include reviewing energy conservation operations, setting conservation targets and labelling the energy conservation performance of equipment in an easy-to-understand manner. Other means may also include subsidies (Box 1) for the introduction of efficient equipment, tax reductions for highly efficient equipment or imposing fines on inefficient equipment, and the provision of incentives through setting appropriate energy prices.

Box 1: India's Bachat Lamp Yojana Scheme

The Indian government's Bureau of Energy Efficiency (IBEE) implemented a scheme to replace incandescent bulbs for lighting with fluorescent bulbs, diffusing 29 million fluorescent bulbs between 2010 and 2013 to save 415 MW in electricity generation capacity. The scheme featured the use of funds under the Clean Development Mechanism to subsidize the gap between incandescent and fluorescent bulb prices (paying €8/CER (Certified Emission Reduction)) to diffuse fluorescent bulbs.

Figure 72 Bachat Lamp Yojana Scheme Mechanism



Source: IBEE

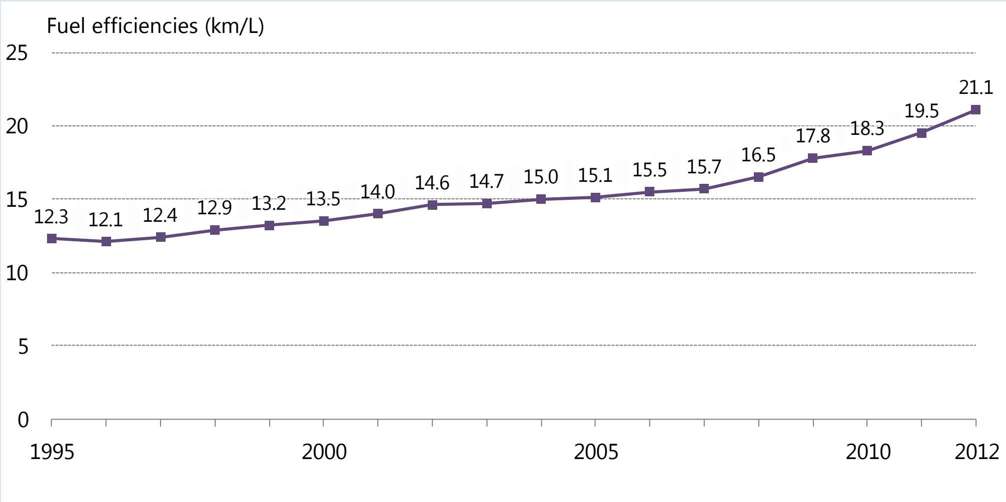
(4) The fourth principle is to ensure the continuous improvement of energy efficiency for equipment (electrical home appliances, vehicles and buildings). Means to promote improvements include establishing energy efficiency standards (such as minimum efficient standards and the Top Runner System (Box 2)) and subsidizing technological development. It

is also important to efficiently use the equipment and implement maintenance measures to keep equipment efficient.

Box 2: Japan's Top Runner System

Japan has implemented the Top Runner System to achieve efficiency improvements for electrical home appliances, vehicles and buildings. For example, the average mileage for new gasoline cars improved by some 74% from 12.1 kilometres per litre (8.3 L/100 km) in 1996 before the introduction of the Top Runner System to 21.1 km/L (4.7 L/100 km) in 2012.

Figure 73 Improvements in fuel efficiencies of gasoline vehicles in Japan



Note: 10-15 mode average fuel efficiencies of gasoline vehicles
Source: Ministry of Land, Infrastructure, Transport and Tourism of Japan

Japan has also introduced the labelling of energy efficiency performance in an easy-to-understand manner to encourage consumers to purchase highly efficient equipment.

Figure 74 Fuel Economy Label in Japan

Source: Ministry of Land, Infrastructure, Transport and Tourism of Japan

(5) Lastly, the fifth principle is to remain informed of future technological innovation. Innovations such as the integration, systematization and automation of multiple machines and the utilization of the Internet of Things are expected to provide new energy conservation means and improve efficiency.

Important for the promotion of energy conservation is to understand its potential and then take action. Anyone can contribute to energy conservation and technological advancements to improve efficiency will continue to play a great role.

Although energy conservation efforts have been made in each country, there still remains a large potential to conserve energy. This is because priorities, policy coverage and the degree of energy conservation differ from country to country depending on national circumstances, as indicated in Table 9. A most common problem is the cost for energy conservation. For as long as priority will be given to cost efficiency rather than energy efficiency, there will be limits on energy conservation efforts. In order to lower barriers and promote energy conservation efforts, the policy means that could be implemented include further technological development for lowering costs, financial assistance and tax incentives for the introduction of energy-efficient equipment.

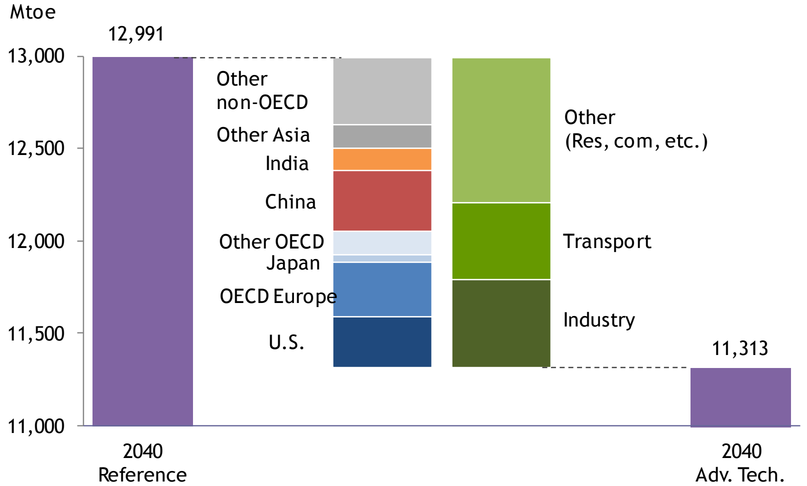
Experiences and best practices for energy conservation have been accumulated in many countries, allowing Japan to share them and learn from overseas cases. In order to promote energy conservation, each country should step up international cooperation to introduce and combine feasible policies and deepen policies in suitable ways in line with the five major energy conservation principles.

Finally, there will be "no end to energy conservation."

5.3 Energy conservation potential

As indicated in Figure 75, in the *Advanced Technologies Scenario*, the maximum energy conservation to reduce global final energy consumption in 2040 will be 1,678 Mtoe (13%) lower than in the *Reference Scenario*, down from 12,991 Mtoe to 11,313 Mtoe. Among sectors, the buildings sector will make the greatest contribution to reducing final energy consumption. The sector's energy conservation will account for 47% of the final energy consumption decline. The buildings sector's energy conservation will depend greatly on improvements in the efficiency of the appliances, such as air-conditioning equipment, refrigerators, water heaters and lighting equipment. Energy consumption on air-conditioning equipment, for example, can be reduced through improvements not only in the efficiency of equipment but also in the insulation performance of buildings which has great potential to cut energy consumption. But such potential may differ from region to region since heating accounts for 60-70% of residential energy consumption in Europe, Russia and Canada while air conditioners capture only less than 30% of residential energy consumption in Japan. In the Middle East, cooling accounts for 70% of residential energy consumption.

Figure 75 Energy saving by region and by sector [2040]



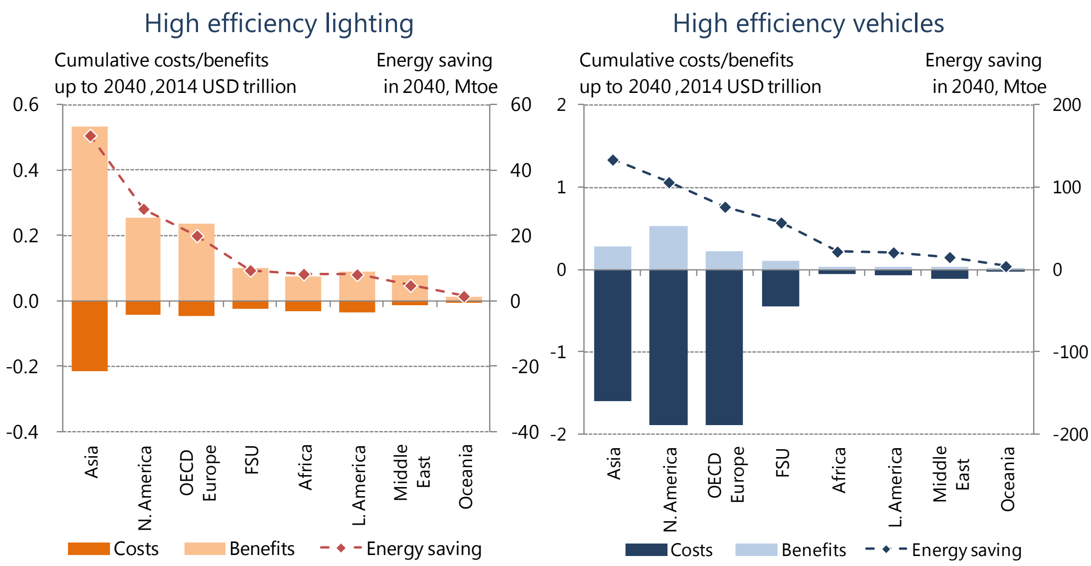
The industry sector will be the second largest contributor to energy conservation, accounting for 28% of the total. Four energy-intensive industries – steel, cement, chemicals, and pulp and paper – account for a large share of the energy consumption in the sector (more than 50% of the global final energy consumption in the industry sector in 2013). The introduction of the most efficient equipment in those four industries will be the greatest energy conservation factor in the industry sector.

Of the transport sector's energy consumption in 2013, vehicles accounted for 75%. So, the improvement of vehicle fuel efficiency will be the most important factor for the sector's energy conservation. Over the long term, particularly, the introduction and spread of next-generation vehicles such as hybrid, electric and fuel cell vehicles will be important keys to energy conservation.

Non-OECD countries will account for 56% of the energy conservation in 2040. On a primary energy consumption basis, including the energy conversion sector's energy conservation through such measures as the improvement of fossil power generation efficiency, non-OECD countries will capture more than 60% of the energy conservation. China and India will account for 20% and 7% of the energy conservation, respectively. Particularly, China will have greater energy conservation potential than any other country. Although Japan's share of energy conservation will be limited to 2.3%, some one-ninth of the Chinese share, it may be needless to say that all countries should make maximum energy conservation efforts, irrespective of their shares.

The introduction of energy conservation measures will lower energy costs, generating benefits for society. In many cases, however, energy conservation requires investments or spending. As indicated in Figure 76, the introduction of light emitting diodes and other highly efficient lights caused additional costs worth $0.4 trillion through 2040 but brought benefits worth about $1.4 trillion via a decline in fuel consumption for power generation, resulting in net benefits worth $1.0 trillion. As for the introduction of next-generation vehicles, however, fuel efficiency improvement benefits may fall short of covering cost hikes, resulting in negative benefits.

Figure 76 Costs and benefits of energy saving

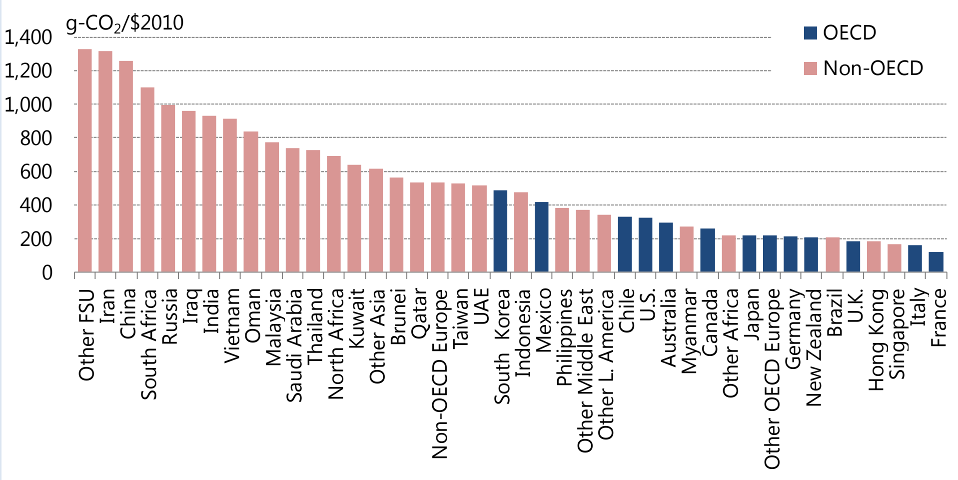


If only measures generating net benefits, such as the introduction of highly efficient lights, are taken into consideration, energy conservation (resulting in a decline in energy-related CO_2 emissions) will have positive effects on the economy. As indicated in Chapter 9, however, these kinds of measures alone will fall short of achieving energy conservation sufficient to address the climate change problem. Therefore, it is important to create policy mechanisms for subsidies and other incentives allowing high-cost technologies to be introduced. Technological development to lower costs and ease the introduction of technologies is also important.

Box 3 If the Japanese levels of energy conservation and decarbonisation are achieved in each country

CO_2 emissions per GDP widely differ from country to country or from region to region (Figure 77). The CO_2 emission intensity is higher for emerging countries other than those that have no energy-intensive industries or are rich with renewable energy sources. If their emission intensity levels are improved to Japanese or European levels, very large CO_2 emission cuts will be achieved. In this sense, emerging countries have great potential to reduce CO_2 emissions.

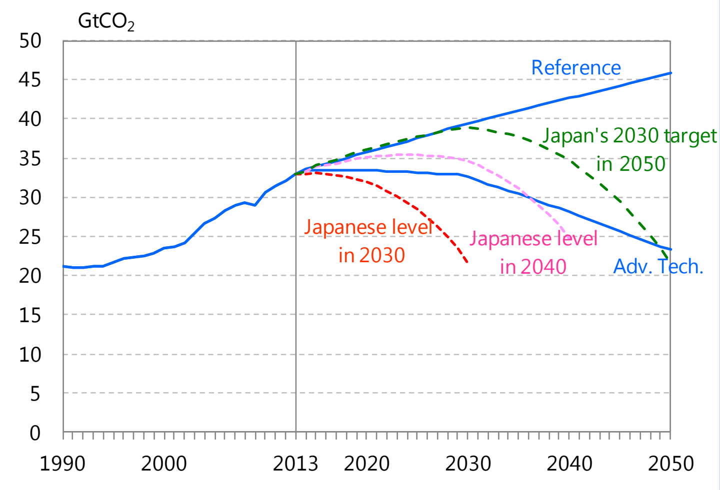
Figure 77 CO_2 intensity by region [2013]



We must take note of the fact that energy demand widely differs from country to country depending on weather and industrial structure conditions. If all countries and regions with higher CO_2 emission intensity levels than in Japan achieve the Japanese level, however, global CO_2 emissions will decline dramatically (Figure 78). If these countries and regions achieve the Japanese level for 2013 in 2030, global CO_2 emissions may be reduced to the 1990 level. Even if the achievement is delayed until 2040, emissions may be less than in the *Advanced Technologies Scenario*. If these countries and regions achieve the Japanese government's present CO_2 emission intensity target[10] for 2030 in 2050, global CO_2 emissions in 2050 will be slightly less than in the *Advanced Technologies Scenario* and 35% less than in 2013. This simple projection indicates that the steady implementation of CO_2 emission reduction measures in countries that have yet to make progress in energy conservation and decarbonisation will be most important for reducing global energy-related CO_2 emissions.

[10] Ministry of Economy, Trade and Industry, "Long-term Energy Supply and Demand Outlook," July 2015 http://www.meti.go.jp/press/2015/07/20150716004/20150716004_2.pdf

Figure 78 Global CO_2 emissions in case of achieving Japanese levels



6. Impacts of technological advancements on energy supply and demand

6.1 Major measures

In the *Advanced Technologies Scenario*, maximum CO_2 emission reduction measures will be implemented with their application opportunities and acceptability to society taken into account. Each country will implement aggressive energy conservation and decarbonisation policies contributing to securing stable energy supply, further enhancing climate change measures, and accelerating the development and introduction of innovative technologies globally. Against the backdrop of the introduction of environmental regulations and national targets, the enhancement of technological development and the promotion of international technological cooperation, the demand side will expand the spread of energy conservation equipment and the supply side will further promote renewable and nuclear energies and introduce carbon capture and storage technologies (Figure 79).

Figure 79 Assumptions for the Advanced Technologies Scenario

Introducing and Enhancing Environmental Regulations and National Targets

Environment Tax, Emissions Trading, RPS, Subsidy Provisions, FIT, Efficiency Standards, Automobile Fuel Efficiency Standard, Low Carbon Fuel Standard, Energy Efficiency Labeling, National Targets, etc.

Promoting Technology Development and International Technology Cooperation

R&D Investment Expansion, International Cooperation on Energy Efficient Technology (steelmaking, cement and other areas), Support for Establishing Energy Efficiency Standards, etc.

【Demand Side Technology】

■ Industry

Under sectoral and other approaches, best available technologies on industrial processes (for steelmaking, cement, paper-pulp and oil refining) will be deployed globally.

■ Transport

Clean energy vehicles (highly fuel efficient vehicles, hybrid vehicles, plug-in hybrid vehicles, electric vehicles, fuel cell vehicles) will diffuse further.

■ Building

Efficient electric appliances (refrigerators, TVs, etc.), highly efficient water-heating systems (heat pumps, etc.), efficient air conditioning systems and efficient lighting will diffuse further, with heat insulation enhanced.

【Supply Side Technology】

■ Renewable Energy

Wind power generation, photovoltaic power generation, CSP (Concentrated Solar Power) generation, biomass power generation and bio-fuel will diffuse further.

■ Nuclear Energy Promotion

Nuclear power plant construction will be accelerated with operating rates improved.

■ Highly Efficient Fossil-fired Power Plant Technology

Coal-fired power plants (USC, IGCC, IGFC) and natural gas MACC (More Advanced Combined Cycle) plants will diffuse further.

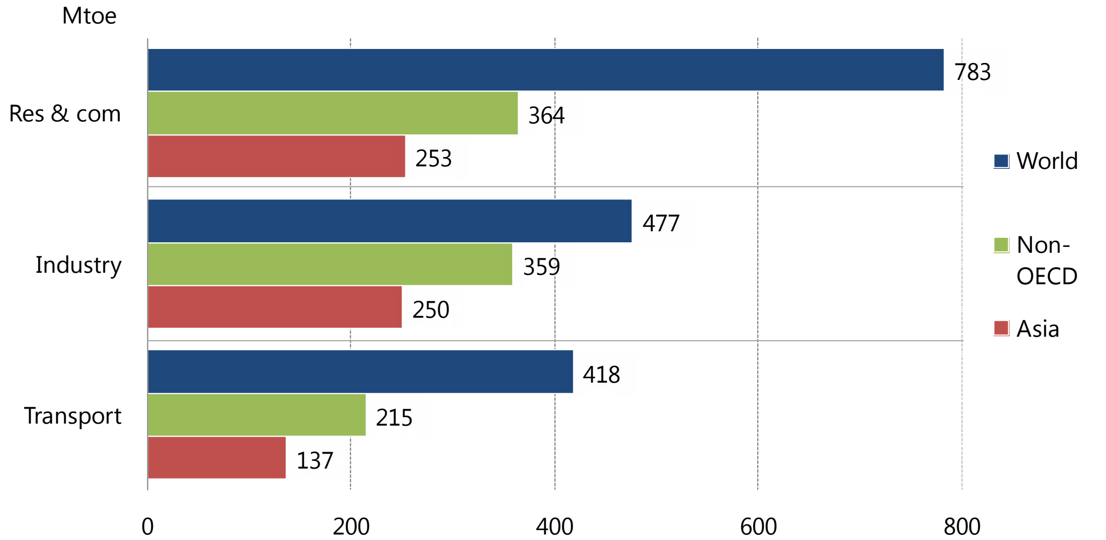
■ CCS

CCS deployment will expand in the power generation sector (new and old coal-fired and gas-fired plants) and the industrial sector (steelmaking, cement and other plants that emit massive GHGs).

Energy conservation

Final energy consumption in the *Advanced Technologies Scenario* will be 1,678 Mtoe less than in the *Reference Scenario*. The energy savings correspond to the present final energy consumption in North America (the United States and Canada). Of the energy savings, the buildings sector will account for 783 Mtoe, the industry sector for 477 Mtoe and the transport sector for 418 Mtoe (Figure 80). Non-OECD countries will capture more than 50% of industry and transport sector energy savings and 47% of buildings sector savings. Whether or not non-OECD countries would realize their potential energy conservation is key to global energy conservation progress. In the following, we explain the characteristics of energy conservation on a sector-by-sector basis in the *Advanced Technologies Scenario.*

Figure 80 Energy saving from the Reference Scenario [2040]

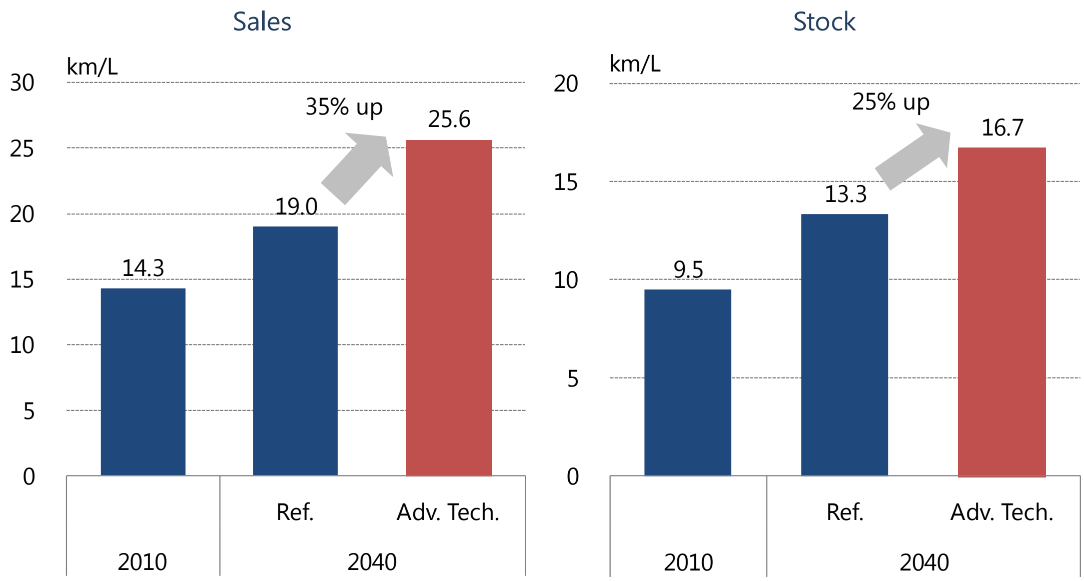


The buildings sector differs from the cost-conscious industry sector in that energy conservation incentives fail to work smoothly. Therefore, both OECD and non-OECD countries have great potential to save energy consumption in the buildings sector. Particularly, energy efficiency improvements for water heating systems in cold regions and insulation improvements in non-OECD countries will make great contributions to saving energy. Since kerosene, liquefied petroleum gas, city gas and other fuels are used for water and air heating in various ways depending on national conditions, fuel consumption will be greatly reduced. But electricity conservation through power and lighting savings will account for more than half of the savings in the whole of the buildings sector.

In the industry sector, non-OECD countries offer great opportunities to improve energy efficiency. Non-OECD energy consumption has remarkably expanded, boosting its share of global energy consumption from 52% in 2000 to 70% in 2013. While non-OECD energy efficiency has been improving due to the introduction of new equipment, energy consumption has been growing as a result of production growth in energy-intensive industries. By applying presently available high-efficiency technologies for steel, chemical, pulp and paper, and other energy-intensive industries, the non-OECD industry sector will reduce energy consumption by 359 Mtoe from the *Reference Scenario.* Asia, where those industries are expected to remarkably expand production, will account for 52% of the energy savings. OECD countries, with less room to improve energy efficiency than non-OECD countries, will cut industry sector energy consumption by 188 Mtoe. OECD countries' technology transfers to non-OECD countries will make great contributions to energy conservation. OECD countries are expected to positively implement such technology transfer programs including energy conservation technology research projects and their joint forums with developing countries.

In the transport sector, fuel efficiency and vehicle fleet mix improvements will make further progress. The global average new vehicle gas mileage in 2040 will improve by 6.6 km/L (1.4 L/100 km) from the *Reference Scenario* to 25.6 km/L (3.9 L/100 km) and the average stock mileage by 3.4 km/L (1.5 L/100 km) to 16.7 km/L (6.0 L/100 km) (Figure 81). Developed countries are expected to introduce and spread next-generation vehicles including plug-in hybrid, electric as well as fuel cell vehicles. The next-generation vehicles' auto fleet share will increase faster in developed countries. Non-OECD countries' share of 418 Mtoe in energy savings in the transport sector from the *Reference Scenario* will be limited to 51%, smaller than in the industry sector.

Figure 81 Improvements in fuel efficiencies



Renewable energy

In the *Advanced Technologies Scenario*, all renewables ranging from hydro to biomass will increase their share of primary energy consumption from 14% in 2013 to 21% in 2040, 5 percentage points higher than in the *Reference Scenario*. Driving the renewable energy share expansion will be wind and solar photovoltaics.

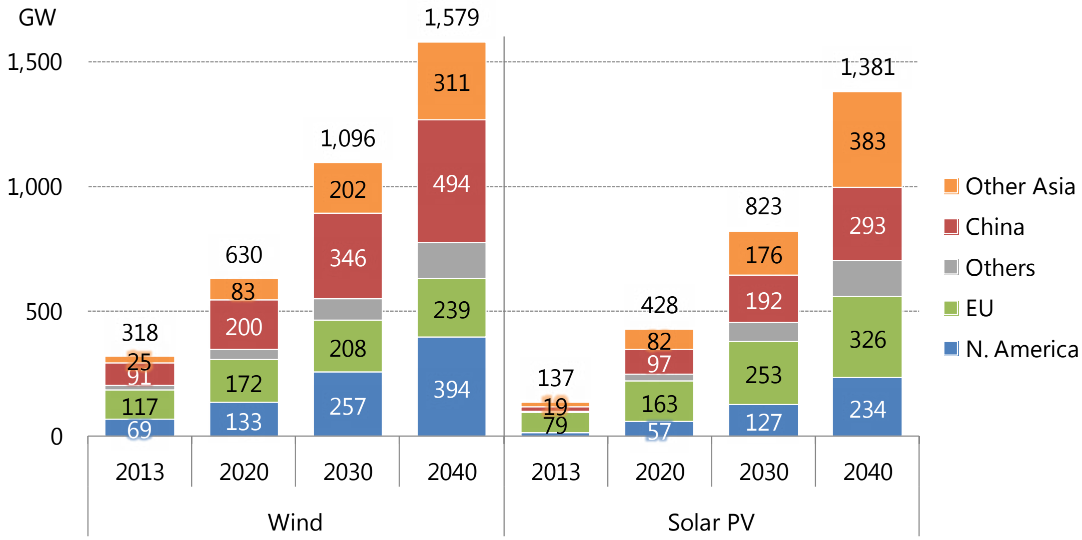
The introduction of onshore wind power generation will accelerate mainly in emerging and developing countries as well as in the United States, as power plant costs are further reduced and electricity transmission and distribution infrastructure is further developed. Offshore wind power generation, on the other hand, will expand mainly in Europe as construction, operation and management, and grid connection costs are reduced (Figure 82). Global installed wind power generation capacity in 2040 in the *Advanced Technologies Scenario* will reach 1,579 GW, about 1.6 times as much as in the *Reference Scenario.*

Solar PV power generation will spread further in emerging and developing countries thanks to lower system costs. Solar PV generation will significantly grow in the Sun Belt (rich with sunlight resources) including China, India, the Middle East, North Africa and Latin America.

In developed countries, lower solar cell prices will be combined with the commercialization of low-cost small storage cells to accelerate the spread of household PV generation. Global installed solar PV generation capacity in 2040 will be 1,381 GW, 1.8 times as large as in the *Reference Scenario*.

Factors for accelerating the spread of wind, solar PV and other intermittent electricity sources include the reduction of construction and system costs, particularly in developing countries where low-cost financing is a major factor. Technologies in output control, generation prediction and storage, combined with network expansion will play major roles in support of these intermittent electricity sources. Smart grid systems combining these technologies will greatly enhance grid stabilization.

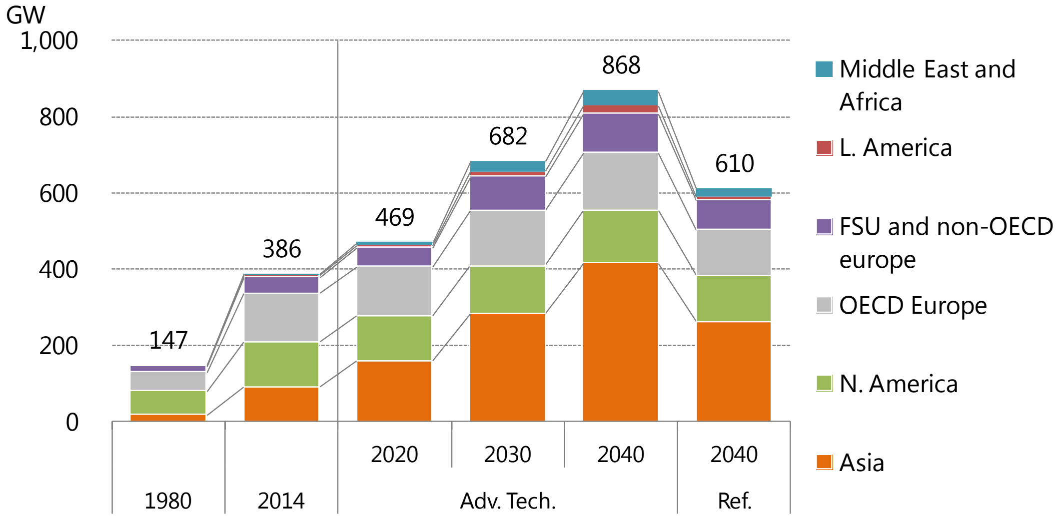
Figure 82 Wind and solar PV power generating capacities by region [Advanced Technologies Scenario]



Nuclear

In the *Advanced Technologies Scenario*, nuclear energy's share of primary energy consumption will rise from 4.8% in 2013 to 10% in 2040, 4 percentage points higher than in the *Reference Scenario.* Installed nuclear power generation capacity will increase from 386 GW in 2014 to 868 GW in 2040, 1.4 times as much as in the *Reference Scenario* at 610 GW.

Figure 83 Nuclear power generating capacity by region



North America will expand its installed nuclear power generation capacity to 139 GW in 2040 due primarily to an increase in the United States. The United States has approved up to 60 years of operation for more than 70% of its existing nuclear reactors and is considering extending their lifetime to 80 years. The extended operation of existing reactors and the net addition with the construction of new ones will boost installed nuclear power generation capacity in the United States to 122 GW in 2040.

OECD Europe will decommission older reactors and construct replacements, eventually increasing installed nuclear power generation capacity in 2040 to 152 GW (from 128 GW in 2014). In the United Kingdom, for example, installed capacity will fall to 11 GW in 2020 on decommissioning of existing reactors and will rise back to 14 GW in 2040. Germany, Switzerland, Belgium and Italy, which adopted a nuclear phase-out policy after the 1986 Chernobyl nuclear plant accident, later restored their policy of using nuclear energy until the 2011 Fukushima accident. The international situation could influence again those policies. Russia will accelerate the construction of new nuclear plants, expanding installed nuclear generation capacity from 25 GW in 2014 to 68 GW in 2040. East European countries are steadily implementing their nuclear energy introduction targets.

China and India, as well as Southeast Asian countries, will make progress in the construction of new nuclear power plants. Asia's installed nuclear power generation capacity will surpass the combined capacity of OECD Europe and North America (at 271 GW) in 2030 and reach 416 GW in 2040. China will increase its installed nuclear generation capacity by some 30 GW every five years, replacing the United States (with capacity at 108 GW) as the world's largest nuclear generating country in 2030. In 2040, the Chinese capacity will reach 192 GW. India, with an installed nuclear capacity limited to only 5 GW in 2014, has put forward a proactive nuclear capacity expansion target boosting its capacity to 53 GW in 2030 and 90 GW in 2040. The Middle East, Africa and Latin America, known as emerging nuclear energy markets, will launch the operation of new reactors around 2025 and steadily expand installed nuclear capacity thereafter. In the Middle East where the United Arab Emirates, Saudi Arabia and other countries are planning to build nuclear power plants, installed nuclear capacity will reach 19 GW in 2030 and 28 GW in 2040.

Great expectations are placed on the introduction of nuclear power generation as a decarbonisation measure. Emerging countries are considering introducing nuclear power generation to meet the rapid growth in domestic electricity demand and promote decarbonisation. The United States, France, Russia and Korea, which have traditionally and proactively promoted nuclear power generation, will extend the lifetime of existing nuclear reactors and build new ones to increase their respective capacities. Germany, Switzerland, Belgium and Italy clarified their nuclear phase-out policy in response to the Fukushima Daiichi nuclear power station accident but could change the policy of phasing-out their nuclear power plant, maintain the present installed capacity or reconsider frozen nuclear plant construction projects.

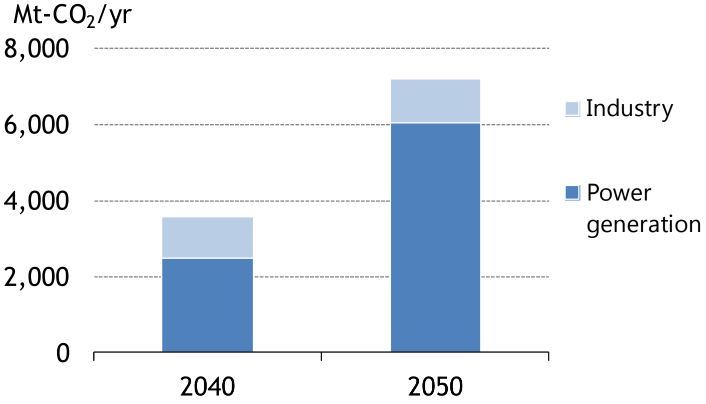
CO_2 capture and storage

Carbon dioxide capture and storage (CCS) technology is an important decarbonisation technology to substantially reduce emissions of CO_2 in the atmosphere while the world remains highly dependent on fossil fuels in the future. CCS technology is expected to develop in large CO_2 emission sources such as the power generation and industry sectors. According to the Global CCS Institute (GCCSI), 55 large-scale CCS projects are underway in the world including North America, China and the United Kingdom. CO_2 capture through ongoing CCS projects is estimated at about 27 Mt per year. Japan's Strategic Energy Plan calls for research and development to commercialize CCS technologies around 2020. Consequently, a CCS demonstration test at an oil refinery in Tomakomai is underway, planning to store 100,000 tonnes of CO_2 per year under pressure into undersea aquifers during the period FY2016 to FY2018.

CCS technology will be used at new fossil fuel power plants, and steelmaking and other industrial processes in line with the enhancement of climate change measures[11]. CO_2 to be captured and stored will increase at a higher pace than at present, reaching 3.6 Gt in 2040 and 7.2 Gt in 2050 (Figure 84). The power generation sector will account for the largest share of CCS.

[11] We assumed that the power generation sector will install CCS equipment at new coal and natural gas power plants to be built from 2030. As for the industry sector where steel and cement manufacturers are expected to introduce CCS equipment, we projected CCS introduction based on crude steel and cement production.

Figure 84 CO_2 emissions reduction by CCS [Advanced Technologies Scenario]

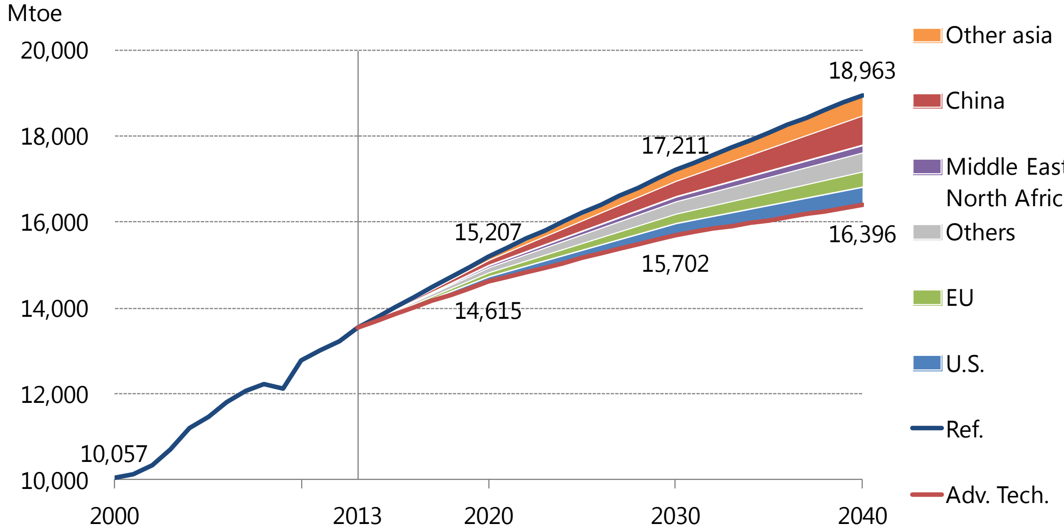


6.2 Energy supply and demand

Primary energy consumption

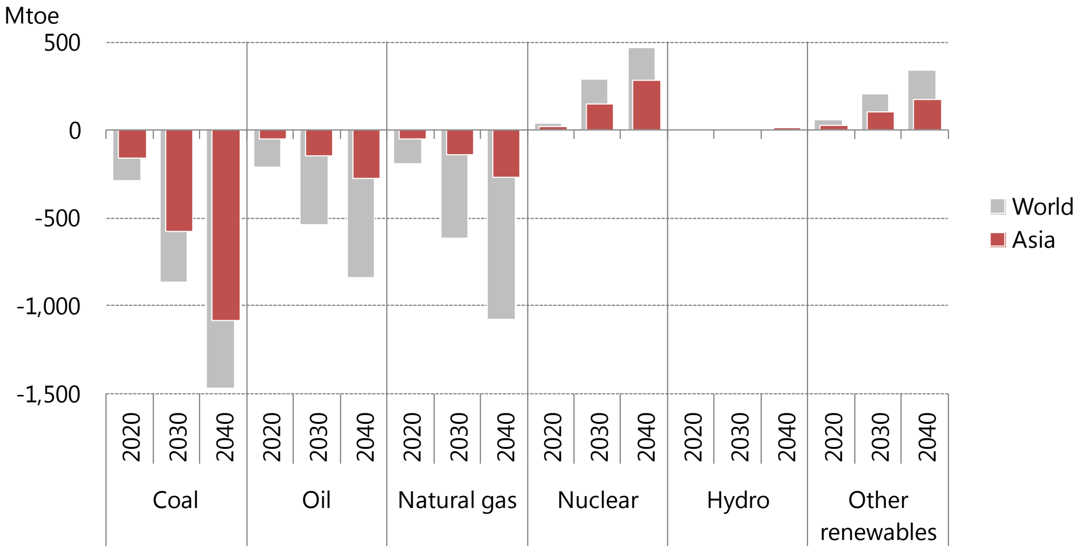
The strong implementation of the abovementioned energy conservation and climate change measures will substantially reduce primary energy consumption (Figure 85). Primary energy consumption in 2040 in the *Advanced Technologies Scenario* will total 16,396 Mtoe, down 2,567 Mtoe from the *Reference Scenario*. The gap corresponds to the present primary energy consumption in North America. Accumulated energy savings through 2040 will total about 34 Gtoe, 2.5 times as much as global primary energy consumption in 2013. In the *Advanced Technologies Scenario*, non-OECD and Asian countries, projected to expand energy demand while offering huge energy conservation potential, will play a great role. Non-OECD countries will account for 61% of global energy conservation in 2040 and Asian countries for 45%. Non-OECD and Asian countries hold the key to reforming the broadly defined global energy system, including consumption and production ways for energy sources required by the world. They influence the global environment.

Figure 85 Primary energy saving by region



Among energy sources, fossil fuels will feature great primary energy consumption savings (Figure 86). Of the 2,567 Mtoe decline in primary energy consumption from the *Reference Scenario* in 2040, coal will account for 1,472 Mtoe, natural gas for 1,076 Mtoe and oil for 839 Mtoe. Meanwhile, nuclear and renewable energy will accelerate their penetration. Nuclear energy consumption in the *Advanced Technologies Scenario* will be 471 Mtoe (including 292 Mtoe in Asia) more than in the *Reference Scenario*. Renewable energy consumption excluding hydro will be 341 Mtoe (including 175 Mtoe in Asia) more. As a result, fossil fuels' share of primary energy consumption in the *Advanced Technologies Scenario* will fall from 81% in 2013 to 70% in 2040.

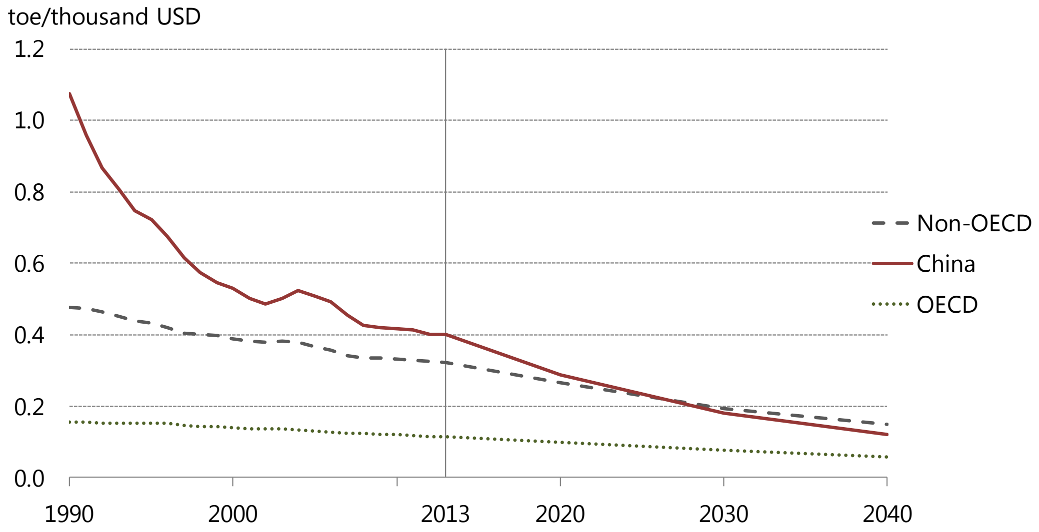
Figure 86 Changes in primary energy consumption from the Reference Scenario



Of fossil fuel consumption savings, Asia, mainly China and India, will account for 48%. Asia will capture as much as 74% of coal consumption savings and will account for more than 50% of nuclear and renewable energy consumption growth.

The world's primary energy consumption per GDP, an indicator of macro energy efficiency, will plunge by 44% from 2013 to 2040. OECD countries will post a moderate decline of 48% against 54% for non-OECD countries. The gap between OECD and non-OECD countries will narrow. China's energy consumption per GDP, which has been rapidly declining due to industrial structure changes, will continue declining and slip below the non-OECD average in the second half of the 2020s. China will later drive non-OECD energy conservation (Figure 87). Asia's energy consumption per GDP will drop by 55% by 2040.

Figure 87 Primary energy consumption per unit of GDP [Advanced Technologies Scenario]

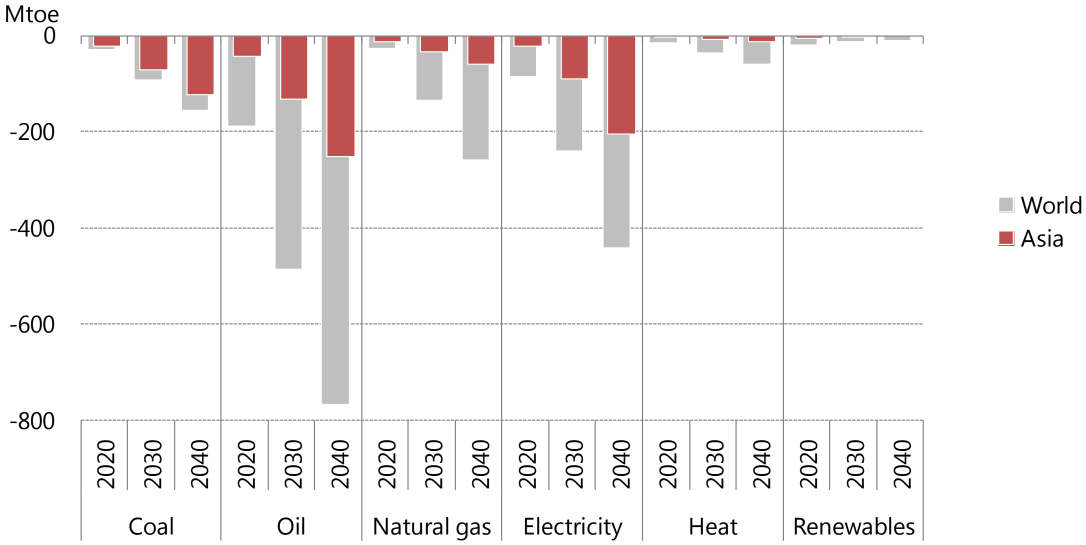


Asia will play a very important role in realizing the global energy system depicted in the *Advanced Technologies Scenario*. Asia must eliminate energy conservation barriers including the lack of fundraising capacity and consciousness that blocks the penetration of technologies. The region must spread energy-saving equipments by offering them at reasonable prices to low-income people and provide energy-saving technologies that take into consideration differences between urban and suburban lifestyles. Each country must implement education programs to enhance energy conservation consciousness on a nationwide basis. Joint forums and other bilateral cooperation schemes, as well as multilateral frameworks such as the ASEAN+3 and Asia Pacific Economic Cooperation forums, will help promote such education.

Final energy consumption

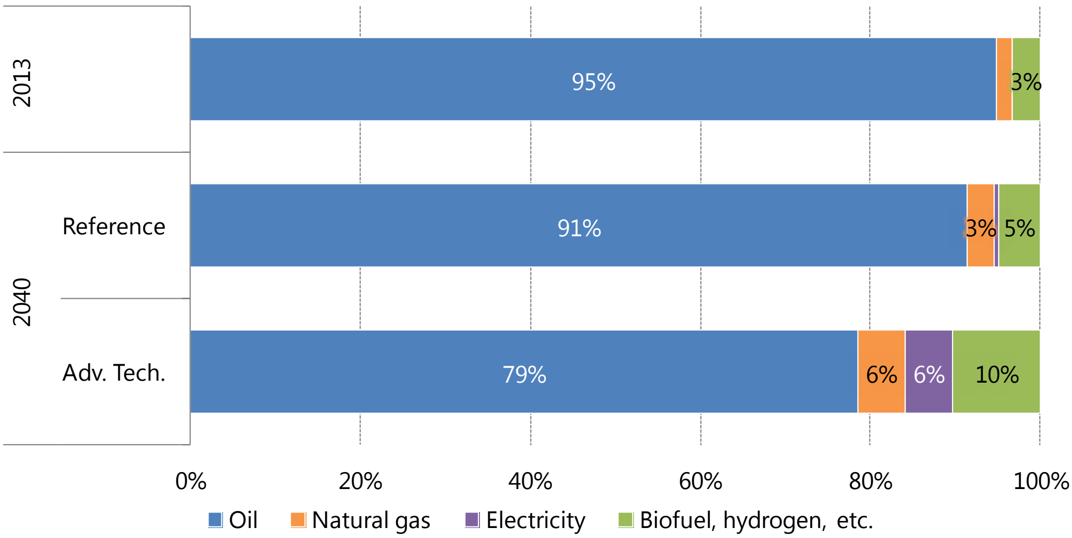
Final energy consumption in 2040 will be lowered by 1,678 Mtoe, of which oil will account for 767 Mtoe and electricity for 441 Mtoe. Oil and electricity will thus cover 72% of energy conservation (Figure 88).

Figure 88 Change in final energy consumption from the Reference Scenario



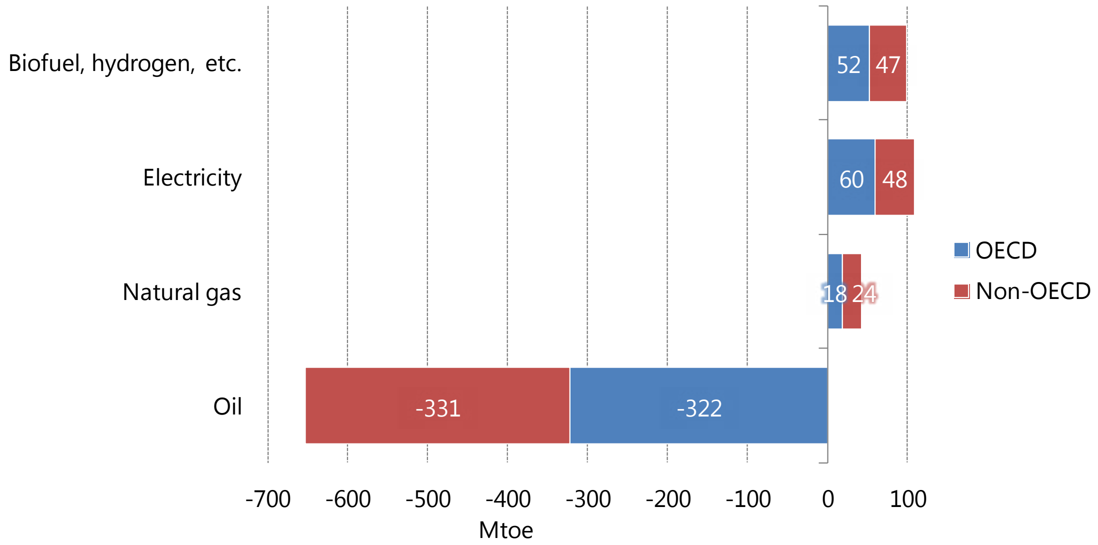
With regard to oil consumption savings, energy conservation progress mainly in the transport sector will make great contributions. In the *Advanced Technologies Scenario*, oil's share of energy consumption in the road sector will decline from 95% in 2013 to 79% in 2040 (Figure 89). As natural gas, electric, fuel cell and other next-generation vehicles spread further, the share for natural gas, electricity, biofuels and hydrogen will reach 21% in 2040.

Figure 89 Energy consumption share (Road sector, World)



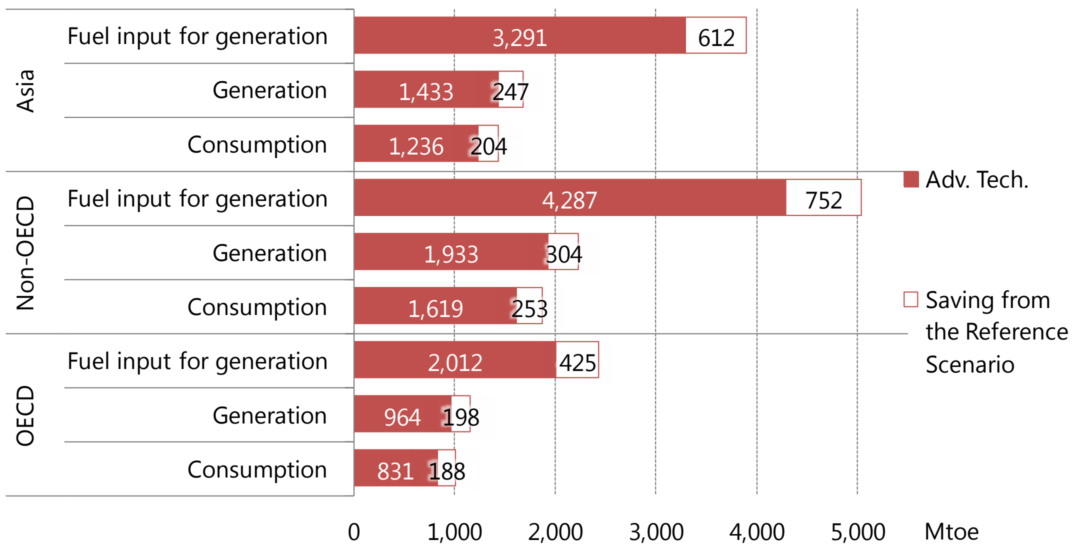
Electricity demand growth will capture the greatest share of energy consumption changes from the *Reference Scenario* in the road sector. In the *Advanced Technologies Scenario*, electric vehicles will spread along with information technologies for traffic demand management to ease congestion and increase distribution efficiency.

Figure 90 Changes in road sector energy consumption from the Reference Scenario [World, 2040]



Final electricity consumption will be reduced by 441 Mtoe, lowering required power generation by 502 Mtoe. The electricity savings will be coupled with power generation efficiency improvement to save primary energy consumption by 1,177 Mtoe (Figure 91). The savings are equivalent to 46% of total primary energy consumption savings. Making great contributions to the savings will be Asia. Through the introduction of new power generation equipment and the replacement of outdated equipment, Asian emerging countries' power generation efficiency will improve to almost the same levels as in developed countries by 2040.

Figure 91 Primary energy reduction by electricity demand saving [Advanced Technologies Scenario, 2040]



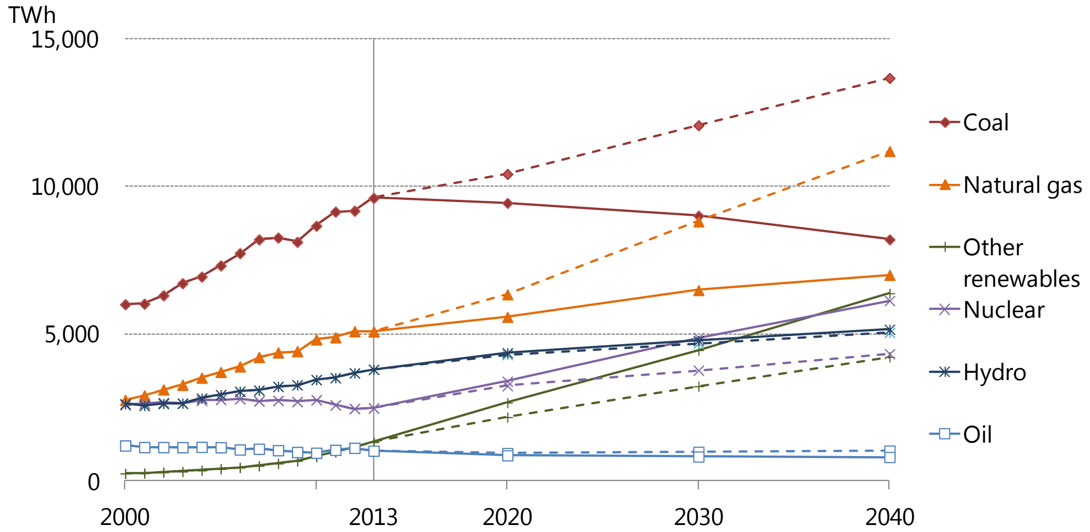
Developed countries should cooperate with Asian emerging countries in improving the latter's power generation efficiency. Emerging countries frequently fail to take into account environmental conservation while giving top priority to high economic growth. For example, efforts to address and solve air pollution problems caused by the industry are likely to suppress economic growth. Therefore, developed countries' cooperation with emerging countries will grow even more important.

Asia will also make great contributions to reducing final coal consumption, accounting for some 80% of the global coal consumption reduction in 2040. In this respect, steelmakers' energy conservation will be important in India and other countries where crude steel production will expand rapidly. Japan's energy consumption per unit of steel production is one of the lowest levels in the world, standing at less than one-third of India's. If highly efficient technologies are transferred from Japan and other developed countries to India and other Asian emerging countries, relevant sectors' energy consumption savings will become more feasible. Developed countries will contribute to energy savings not only in energy-saving equipment and other hardware but also in software including equipment operations.

Electricity generation mix

In the *Advanced Technologies Scenario*, final energy consumption savings will work to cut electricity generation by about 5,839 TWh, about six times as much as Japan's electricity generation. In this scenario, the integrated gasification combined cycle (IGCC) for coal-fired electricity generation and the development of technology for mixing coal with biomass energy will contribute to cutting coal consumption for electricity generation (Figure 92). Natural gas, nuclear energy and renewables will increase their presence in electricity generation while coal will diminish.

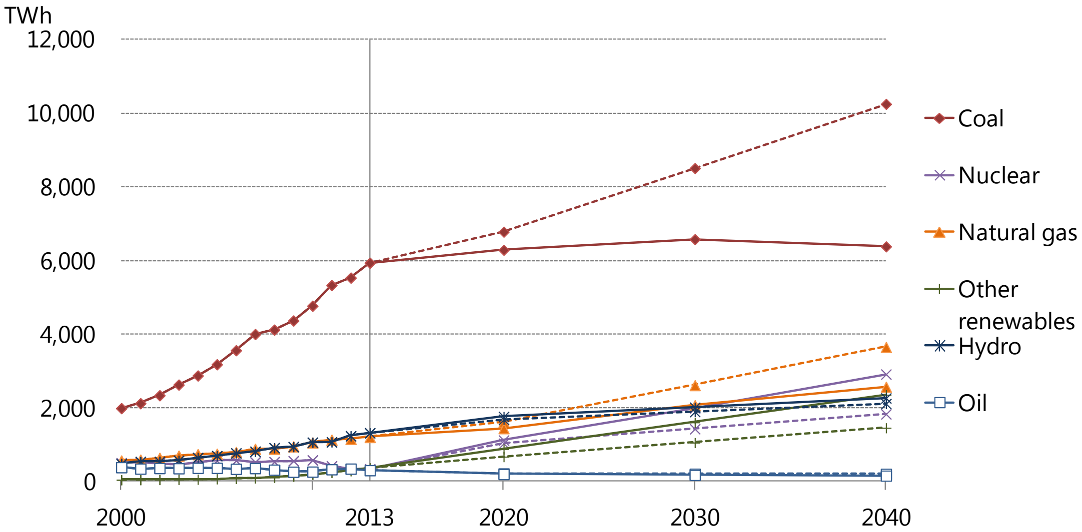
Figure 92 Global power generation by source [Advanced Technologies Scenario]



Note: Dashed lines represent the Reference Scenario

In Asia, as well as in the rest of the world, coal-fired power generation will be reduced substantially. Nevertheless, coal's share of electricity generation in 2040 in Asia will still be larger than in any other region (Figure 93). As China and other Asian countries are promoting the introduction of renewable energy technology, it is important for them to reduce coal-fired power generation.

Figure 93 Asian power generation by source [Advanced Technologies Scenario]



Note: Dashed lines represent the Reference Scenario

In addition to technologies for improving power generation efficiency to reduce primary energy consumption, technologies for limiting electricity consumption itself are important. A particularly key challenge is how to restrict electricity consumption in the buildings sector that typically increases in line with living standard improvements. Home energy management system (HEMS) including smart meters, building energy management system and other technologies to control energy consumption are expected to spread in developed countries and later be transferred to emerging countries.

Crude oil supply

Table 10 indicates an outlook for crude oil supply. Global oil demand will continue increasing even in the *Advanced Technologies Scenario*, but the increase will be far slower than in the *Reference Scenario*. Oil demand in 2040 in the *Advanced Technologies Scenario* will be 17.4 Mb/d less than in the *Reference Scenario*. As oil demand growth slows down, competition between oil suppliers will become fiercer. Finally, cost-competitive OPEC crude oil will expand its share of the global market, forcing the non-OPEC share in 2040 to fall to 55%. While relatively cost-competitive shale oil production in the United States will still continue, the former Soviet Union will gradually reduce production, failing to provide additional supply sufficient to offset the depletion of currently operating oil fields.

Table 10 Crude oil production [Advanced Technologies Scenario]

(Mb/d)

	2013	2020	2030	2040	2013-2040
Total	88.77	91.02	94.90	96.20	+7.43
OPEC	36.63	35.52	39.50	42.30	+5.68
Middle East	26.84	25.65	29.10	32.00	+5.16
Others	9.79	9.87	10.40	10.30	+0.51
Non-OPEC	49.95	53.00	52.40	50.60	+0.65
North America	14.05	16.10	15.50	15.00	+0.95
Latin America	7.00	8.30	8.80	8.80	+1.80
Europe and Eurasia	17.16	16.50	15.80	14.85	-2.31
Middle East	1.36	1.35	1.25	1.30	-0.06
Africa	2.11	2.90	2.80	2.80	+0.69
Asia	8.28	7.85	8.25	7.85	-0.43
China	4.22	3.90	3.70	3.60	-0.62
Indonesia	0.88	0.80	0.70	0.65	-0.23
India	0.91	0.70	0.70	0.45	-0.46
Processing gains	2.20	2.50	3.00	3.30	+1.10

Natural gas supply

In the *Advanced Technologies Scenario* where energy and environmental policies contributing to securing stable energy supply and enhancing climate change measures will be strongly implemented, global natural gas production in 2040 will be 23% less than in the *Reference Scenario* in line with smaller demand. Demand will decline more remarkably in North America and OECD Europe where renewable energy and energy conservation technologies will be deepened, exerting great negative effects on their supply sources including production in North America and non-OECD Europe/Central Asia including Russia. Production in 2040 will decrease by 335 Bcm from the *Reference Scenario* to 856 Bcm in the *Advanced Technologies Scenario* for North America and by 200 Bcm to 1,072 Bcm for non-OECD Europe/Central Asia. The Middle East's production expansion will be limited to a far lower level than in the *Reference Scenario*. As natural gas demand in Asia including China and India increases at an annual rate of 3% through 2040 even in the *Advanced Technologies Scenario*, Asian natural gas production will grow at an annual rate of 2%, though failing to catch up with demand growth.

Table 11 Natural gas production [Advanced Technologies Scenario]

(Bcm)

	2013	2020	2030	2040	2013-2040
Total	3,530	3,843	4,209	4,447	+917
Unconventional	394	570	929	1,115	+722
North America	849	939	965	856	+7
Unconventional	361	488	608	599	+239
Latin America	227	229	267	301	+74
Unconventional		5	83	135	+135
OECD Europe	265	210	180	139	-125
Unconventional			9	13	+13
FSU/Non-OECD Europe	911	978	1,036	1,072	+161
Russia	627	675	694	697	+70
Unconventional			23	38	+38
Middle East	563	573	633	701	+138
Unconventional			13	21	+21
Africa	206	226	318	409	+203
Unconventional			3	16	+16
Asia	441	536	641	795	+354
China	124	210	268	342	+218
Unconventional	25	36	102	157	+132
South Asia	90	102	161	212	+122
Unconventional		0	16	30	+30
Southeast Asia	222	221	223	239	+17
Unconventional		7	25	33	+33
Oceania	68	151	169	174	+105
Unconventional	8	35	61	78	+70

Coal supply

In the *Advanced Technologies Scenario,* global coal demand will decline as a switch from coal to other energy sources makes progress with coal consumption efficiency improved. As a result, global coal production will decrease from 8,075 Mt in 2013 to 6,308 Mt in 2040. Steam coal production will decline from 6,195 Mt in 2013 to 5,112 Mt in 2040. Coking coal production will fall from 1,045 Mt in 2013 to 776 Mt in 2040. Lignite production will drop from 835 Mt in 2013 to 420 Mt in 2040. Coal production in 2040 in the *Advanced Technologies Scenario* will be 3,110 Mt less than in the *Reference Scenario*. Production will be 2,629 Mt less for steam coal, 129 Mt less for coking coal and 351 Mt less for lignite (Figure 94). Table 12 indicates steam coal production by region and Table 13 coking coal production by region.

Figure 94 Coal production by type [Advanced Technologies Scenario]

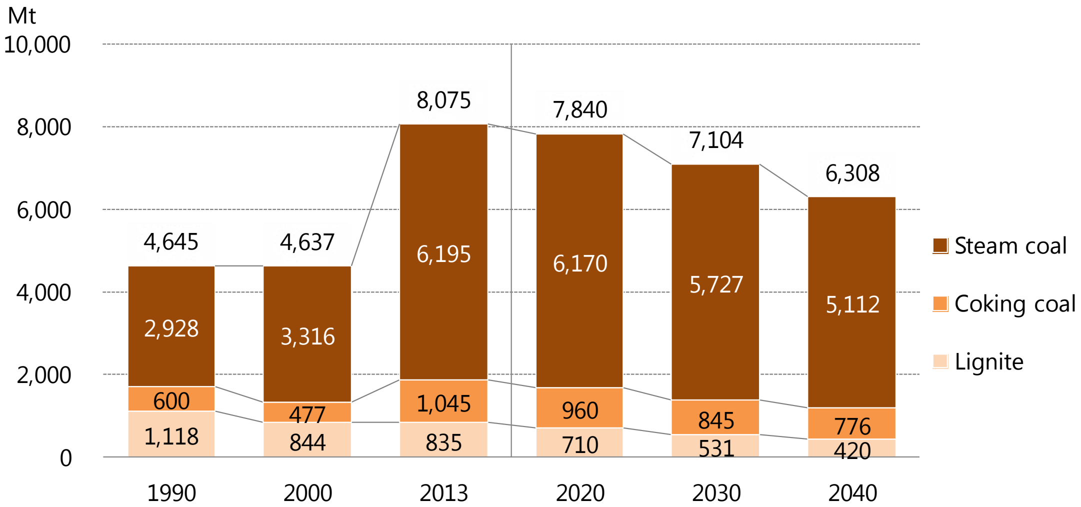


Table 12 Steam coal production [Advanced Technologies Scenario]

(Mt)

	2013	2020	2030	2040	2013-2040
World	6,195	6,170	5,727	5,112	-1,082
North America	782	641	435	232	-550
United States	756	622	425	227	-529
Latin America	104	105	94	86	-18
Columbia	81	80	66	55	-26
OECD Europe	94	82	56	37	-57
FSU/Non-OECD Europe	335	326	273	242	-93
Russia	179	186	161	136	-42
Middle East	0	0	0	0	0
Africa	261	303	316	333	+72
South Africa	253	289	296	306	+53
Asia	4,381	4,419	4,251	3,881	-500
China	3,282	3,269	3,009	2,478	-804
India	516	632	682	792	+276
Indonesia	484	420	441	464	-20
Oceania	239	293	302	303	+64
Australia	237	292	300	301	+64

Table 13 Coking coal production [Advanced Technologies Scenario]

(Mt)

	2013	2020	2030	2040	2013-2040
World	1,045	960	845	776	-270
North America	112	101	98	93	-19
United States	78	75	73	70	-7
Latin America	5	4	4	4	-1
Columbia	4	4	4	4	-0
OECD Europe	22	20	17	15	-7
FSU/Non-OECD Europe	106	101	99	95	-11
Russia	74	67	67	66	-8
Middle East	1	1	1	1	0
Africa	7	12	13	17	+10
Mozambique	3	9	11	15	+11
Asia	629	570	468	409	-220
China	562	495	392	329	-232
India	50	59	60	65	+15
Mongolia	15	12	11	9	-7
Oceania	162	150	146	141	-21
Australia	159	148	144	140	-20

7. Impacts of low oil prices caused by loose supply-demand balance

7.1 Position of Lower Price Scenario

In the *Lower Price Scenario*, the oil supply-demand balance is assumed to ease substantially. The implementation of energy and environmental measures contributing to securing stable energy supply and enhancing climate change measures stimulates the development of unconventional oil and gas resources on the supply side. The same measures will restrict fossil fuel consumption on the demand side. Real crude oil prices in 2030 are assumed to rise back to $75/bbl in the *Lower Price Scenario* against $100/bbl in the *Reference Scenario.*

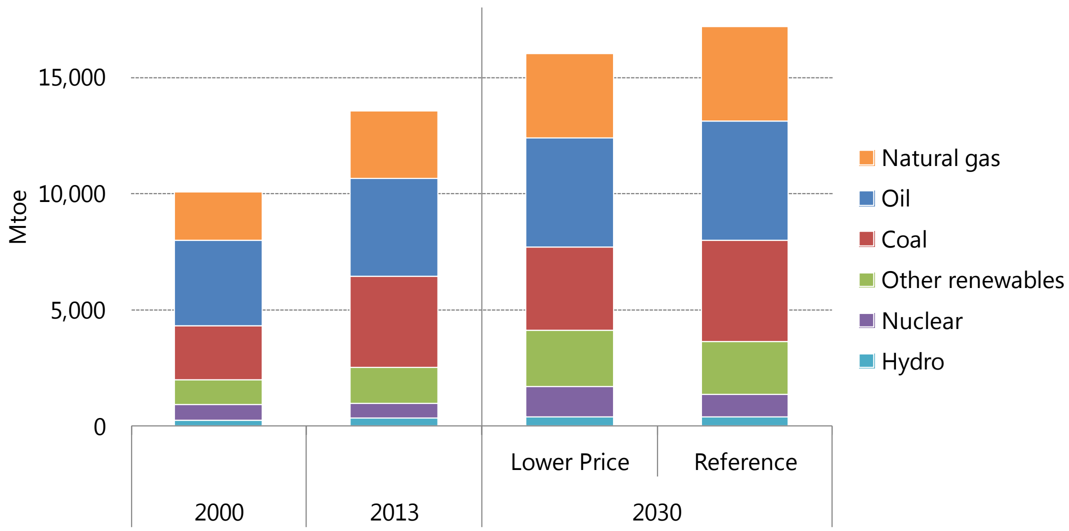
In this chapter, we focus the analysis on 2030.

7.2 Energy demand

Primary energy consumption

In the *Lower Price Scenario*, the world energy supply required in 2030 will be limited to 16,048 Mtoe (Figure 95), 1,163 Mtoe less than in the *Reference Scenario.* As noted above, the effects of energy conservation to be promoted strongly will outdo those of global economic expansion or rebound to be caused by energy price declines. Fuel switching will also affect fossil fuel consumption. Of the energy supply, oil and natural gas will account for 4,689 Mtoe and 3,635 Mtoe, respectively. The *Reference Scenario* increase will be reduced by half for oil and one third for natural gas.

Figure 95 Global primary energy consumption [Lower Price Scenario, 2030]



7.3 Energy supply and trade

Crude oil supply

Table 14 presents the crude oil supply outlook. In the *Lower Price Scenario*, energy demand will be restricted due to technological innovation in transport and other sectors. On the supply side, the shale revolution will make progress not only in North America but also in the rest of the world. Oil producing countries will also compete for expanding production, with Saudi Arabia and some others decreasing production to counter growth in Iran and Iraq within OPEC. Shale oil will become more competitive, with global production expanding to 8.9 Mb/d in 2030. The OPEC production increase between now and 2030 will be limited to 1.2 Mb/d. Iran and Iraq will raise production by more than 2.9 Mb/d, while Saudi Arabia will cut production by 1.3 Mb/d. As a result, OPEC will fall short of expanding its share of the global market as much as in other scenarios. Its share in 2030 will be limited to 39%.

Table 14 Crude oil production [Lower Price Scenario]

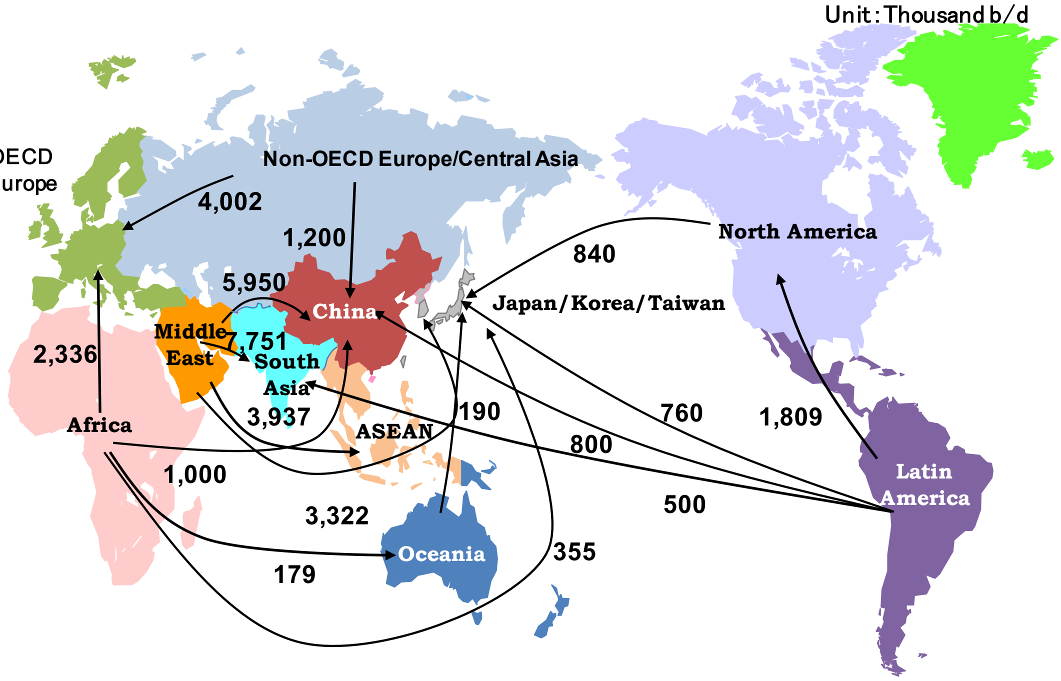
(Mb/d)

		Lower Price			Reference
	2013	2020	2030	2013-2030	2030
Total	88.77	91.22	96.50	+7.73	106.00
OPEC	36.63	35.02	37.80	+1.18	44.80
Middle East	26.84	25.45	28.00	+1.16	33.10
Others	9.79	9.57	9.80	+0.01	11.70
Non-OPEC	49.95	53.70	55.70	+5.76	58.20
North America	14.05	16.70	17.30	+3.25	16.90
Latin America	7.00	8.30	10.30	+3.30	9.80
Europe/Eurasia	17.16	16.60	15.90	-1.26	18.50
Middle East	1.36	1.35	1.15	-0.21	1.55
Africa	2.11	2.60	2.80	+0.69	3.00
Asia	8.28	8.15	8.25	-0.03	8.45
China	4.22	3.90	3.90	-0.32	3.70
Indonesia	0.88	0.90	0.70	-0.18	0.90
India	0.91	0.80	0.70	-0.21	0.70
Processing gains	2.20	2.50	3.00	+0.80	3.00

Crude oil trade

As oil demand is restricted worldwide, with supply increasing from North America and other non-OPEC oil producing regions, crude oil trade in 2030 will be limited to 38.7 Mb/d. The amount of crude oil trade will be almost unchanged from 2014; but the trade flows will greatly change over time (Figure 96).

Figure 96 Major crude oil trade flows [Lower Price Scenario, 2030]



The United States will reduce net imports from 6.4 Mb/d in the *Reference Scenario* to 5.0 Mb/d as domestic demand falls and domestic production increases. Its import sources will be limited to Canada and Latin America. The Americas will thus become almost self-sufficient in crude oil with the U.S. exports that will more than double from 0.4 Mb/d in the *Reference Scenario* to 1.0 Mb/d, including those for Asia. Europe will receive crude oil supply primarily from the former Soviet Union and Africa as in the *Reference Scenario*. Imports from the Middle East will be cut to zero from a small amount in the *Reference Scenario* as the Middle East faces growing competition from the former Soviet Union and Africa. In this way, both the United States and Europe will no longer be dependent on Middle Eastern crude oil.

China will reduce crude oil imports by about 20% from the *Reference Scenario* as domestic production remains robust with demand growth restricted. As Latin America will be forced to export crude oil to non-U.S. markets, China imports from Latin America will be increasing. Given that China promotes diversification of crude oil supply sources as its top priority for energy security and that Chinese state-run oil companies produce crude oil at overseas locations, China will also expand imports from the former Soviet Union and Africa. As a result, Middle Eastern crude oil's share of China's total crude imports will remain dominant but limited to around 66%. China will diversify its crude oil import sources in the *Reference Scenario* as well as in the *Lower Price Scenario,* resulting in a fall in its dependence on the Middle East.

Japan, Korea and Chinese Taipei will greatly reduce imports due to lower demand. While Japan has already begun to reduce its oil refining capacity, Korea with a surplus capacity of more than 1 Mb/d is expected to do so toward 2030. Although Japan, Korea and Chinese Taipei will expand imports from the United States and Latin America, the Middle East will remain an important exporter. The Middle East's share of imports into the three economies will fall from 74% in the *Reference Scenario* to 61% in the *Lower Price Scenario*. Japan, Korea and Chinese Taipei will thus diversify their import sources.

Natural gas supply

The supply-demand balance globally eases in the *Lower Price Scenario.* Total natural gas production in 2030 will decline by 12.4% from the *Reference Scenario* due to lower demand, the result of the implementation of energy and environmental measures. Since production costs for shale and other unconventional natural gas are assumed to smoothly drop, North America will expand production, despite a domestic demand decrease, taking advantage of exports. Canada, Argentina, China and Europe will also boost shale gas production after 2020. As a result, unconventional natural gas will increase its share of total production to 29.4% in 2030. Consequently, conventional natural gas producers (non-OECD Europe/Central Asia and the Middle East) will reduce their share of global natural gas production from the *Reference Scenario*.

Table 15 Natural gas production [Lower Price Scenario]

(Bcm)

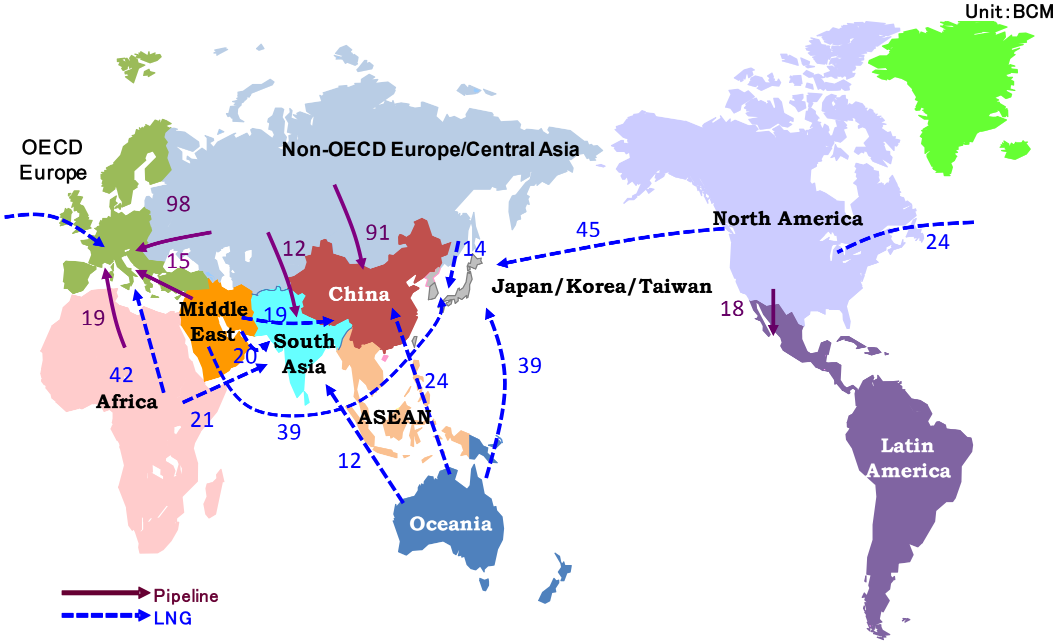
		Lower Price			Reference
	2013	2020	2030	2013-2030	2030
Total	3,530	3,889	4,355	+825	4,971
Unconventional	394	689	1,108	+714	1,070
North America	849	973	979	+130	1,107
Unconventional	361	516	627	+266	686
Latin America	227	232	312	+85	329
Unconventional		12	109	+109	109
OECD Europe	265	235	246	-19	243
Unconventional		7	15	+15	5
FSU/Non-OECD Europe	911	932	937	+26	1,139
Russia	627	624	609	-18	763
Unconventional		19	47	+47	23
Middle East	563	578	646	+83	858
Unconventional		23	39	+39	17
Africa	206	231	346	+140	369
Unconventional		12	28	+28	11
Asia	441	558	712	+271	736
China	124	240	322	+198	288
Unconventional	25	48	122	+97	101
South Asia	90	91	126	+36	178
Unconventional		5	14	+14	16
Southeast Asia	222	224	261	+39	267
Unconventional		11	34	+34	32
Oceania	68	151	177	+109	190
Unconventional	8	38	74	+66	70

Natural gas trade

In the *Lower Price Scenario*, interregional natural gas trade in 2030 will be limited to 700 Bcm as natural gas production in Asia steadily increases, with OECD Europe preventing any production fall. Exports from non-OECD Europe/Central Asia and the Middle East will grow little from 2020, while North American exports will increase faster than in the *Reference Scenario*.

As in the *Reference Scenario*, any increase in net exports from North America, Oceania and non-OECD Europe/Central Asia will mostly be destined to Asia. Since unconventional natural gas is assumed to grow more competitive in the *Lower Price Scenario*, North America will export 45 Bcm more to Japan, Korea and Chinese Taipei and 23 Bcm more to Europe than in the *Reference Scenario*. Meanwhile, pipeline gas supply from non-OECD Europe/Central Asia will be limited to 98 Bcm for OECD Europe and 95 Bcm for China, far less than in the *Reference Scenario*.

Figure 97 Major natural gas trade flows [Lower Price Scenario, 2030]

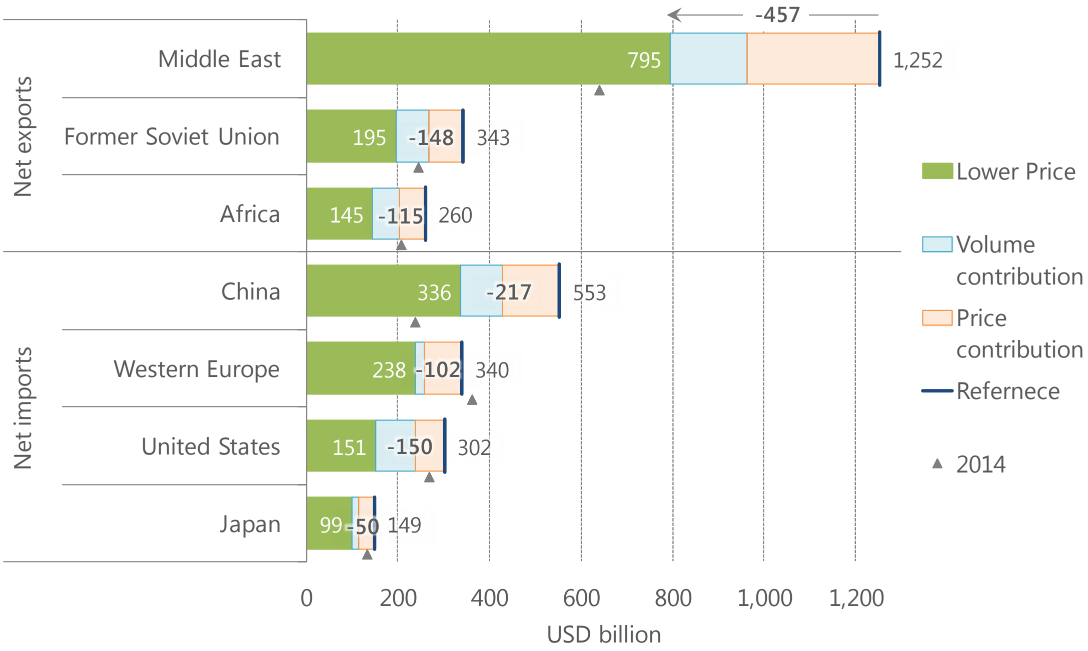


7.4 Economy

Net value of crude oil exports

As oil demand is restricted and real crude oil prices set at 25% lower than in the *Reference Scenario*, the net nominal value of crude oil imports and exports in the *Lower Price Scenario* will be far less than in the *Reference Scenario* (Figure 98).

Figure 98 Impact of lower prices on crude oil import/export bills in selected regions and countries [2030]



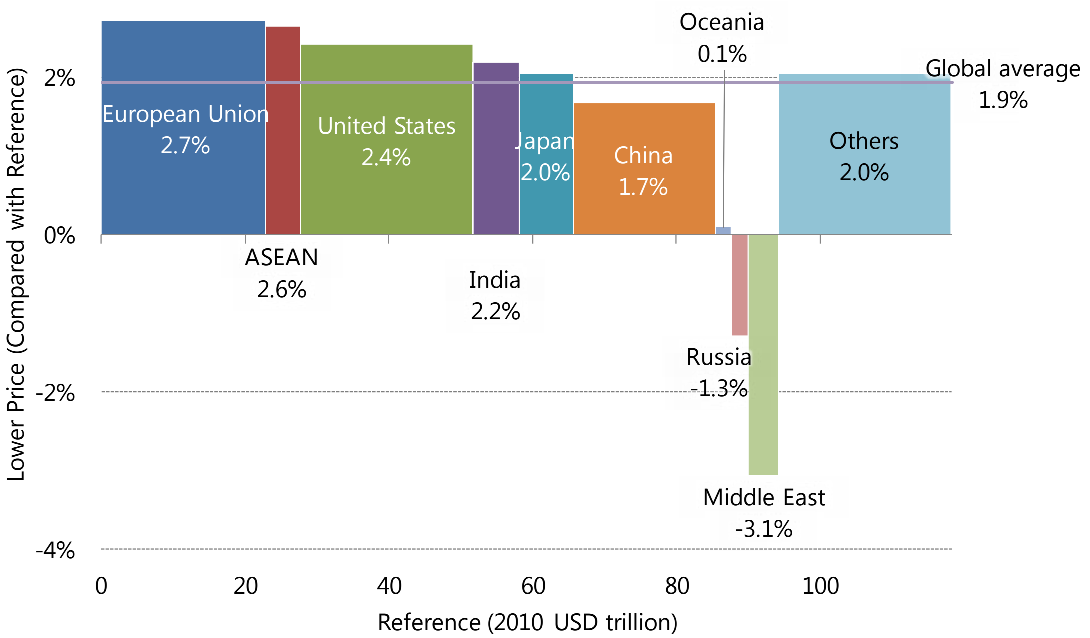
China will benefit the most from a decline in crude oil import costs. The drop in import costs from the *Reference Scenario* in 2030 will be $217 billion, almost equivalent to China's 2014 annual crude oil imports ($228 billion). Lower energy prices, fuel switching to natural gas and lower domestic demand are contributing to the decline in the cost of China's crude oil imports. The United States is the second largest beneficiary from a drop in the value of crude oil imports. Shale oil production growth and oil consumption savings will account for 60% of the net decline. For most of the other crude oil importers, the lower levels of prices capture the greatest share of the drop in the cost of crude oil imports.

Meanwhile, by 2030, Middle Eastern oil producing countries' net exports are valued at $457 billion less than in the *Reference Scenario*. The difference is similar to the Middle East's Asia-bound crude oil exports in 2014 (about $470 billion). The decline will become a major economic downside factor for Middle Eastern oil producing countries that depend on energy export income for revenues. The net value of crude oil exports will be $148 billion less than in the *Reference Scenario* for the former Soviet Union and $115 billion less for Africa. The declines in value will be one-fourth to one-third of the Middle Eastern drop. In percentage, however, their drops will exceed the 36% for the Middle East at 43% and 44% respectively.

Real GDP

In the Lower Price Scenario, the world's real GDP for 2030 will increase by 1.9% from the *Reference Scenario* (Figure 99).

Figure 99 Impact on real GDP in 2030



The European Union, which accounts for 20% of global real GDP, will get greater economic benefits than any other country or region. The European Union, though now depending on imports for 90% of its oil and natural gas supply, will take advantage of lower energy prices and lower imports to reduce industrial production costs and enhance its export competitiveness. It will thus hold down wealth outflow. The European Union's real GDP will increase by 2.7% from the *Reference Scenario* in 2030

In the United States, the drop in energy prices will weaken earnings for the oil and natural gas industry, exerting adverse effects on that part of the economy. Nevertheless, the economic impacts for the whole of the U.S. economy will be positive in 2030 as it remains a net oil importer. Given that private consumption accounts for as much as 70% of GDP, consumers will greatly benefit. A decline in the share of energy-related spending relative to disposable income has already been observed under the current low crude oil prices. If disposable income increases through energy price drops, consumers may expand consumption including vehicle purchases. In response to such demand growth, companies will increase employment, creating a virtuous circle. Given these points, the U.S. economy will grow by 2.4% from the *Reference Scenario.*

Asia, heavily dependent on energy imports, will greatly benefit from lower energy prices. The ASEAN economy will expand by 2.6% from the *Reference Scenario* in 2030, with economic effects as high as the European Union. Real GDP in 2030 will increase by 2.2% from the *Reference Scenario* for India and by 1.7% for China. In Japan that depends on imports for more than 90% of its energy supply, the economy will grow by 2.0% from the *Reference Scenario* in 2030. Many countries will save fuel and transport costs at the company levels and these savings will be used for expanding infrastructure development and corporate capital investment. Indonesia and Malaysia will experience a temporary consumption plunge as domestic energy prices rise due to reduced or eliminated fuel subsidies. The subsidy reduction or elimination will in turn improve their fiscal and current balances to advantage their economies.

Meanwhile, the Middle East's real GDP in 2030 will decline by 3.1% from the *Reference Scenario.* In the outlook period through 2040, Middle Eastern oil producing countries will accelerate their fiscal reform, including the reduction or elimination of subsidies for gasoline and diesel oil that will reduce consumption as energy prices rise. The global growth in unconventional resources development will further weaken the Middle East's presence as producers. This trend has already emerged under low crude oil prices. Kuwait is considering repealing subsidies for meat in anticipation of fiscal difficulties while King Salman bin Abdulaziz Al Saud of Saudi Arabia is now reconsidering its January 2015 promise regarding electricity and water subsidies. The United Arab Emirates have withdrawn their energy subsidies with gasoline prices already increasing by more than 20%.

Russia endowed with rich energy resources will maintain its government system where political power is based on the redistribution of income from natural gas and other energy development. Therefore, as pressure will grow on its fiscal balance, Russian real GDP will contract by 1.3% from the *Reference Scenario.*

World should increase talks for stabilising energy markets

As energy prices remain low, the Middle East, Russia and other countries, rich with energy resources, are vulnerable of concentrating too much of their economic activities in the energy sector. The Middle East and Russia have tried to diversify their economies but except for the UAE already facing less and less oil resources, the diversification have been slow. In an era of low energy prices, the Middle East and Russia should take note of their vulnerability and take advantage of the low energy prices to promote medium- to long-term efforts to diversify their economies. Specifically, the Middle East should exploit savings from their ongoing subsidy reduction or elimination for accelerating economic diversification. In that process, the region will have to develop an investment climate including security, sanitation and working conditions to attract foreign investment.

Even in countries that benefit from energy price falls, stock price drops for resource-related and other companies could destabilise the stock market, causing a negative chain reaction that will dampen consumption. Energy prices perceived to be much lower than anticipation and destabilising of many markets, could block appropriate investment.

Some predict that North America will slowly reduce unconventional energy resources production through 2020. Then, only Middle Eastern oil producing countries will be able to fulfil the growing energy demand in emerging countries. Over a longer term beyond 2030, the Middle East could increase its presence again.

Therefore, the world should not be relieved to see the end of the high energy price age. In an era of low energy prices, energy producing and consuming countries should participate in each other's territories to build a structure benefiting both and should share information and understanding to reduce uncertainties. For example, the ongoing scheme for Asian natural gas procurement cooperation would be an important case. The natural gas supply chain includes not only gas consuming countries but also upstream gas development, gas liquefaction and transport. Asian countries should be united to participate in the natural gas production process to help stabilise procurement and break the natural gas supply structure dominated by international oil majors, contributing to the elimination of the so-called Asian premium on gas prices.

In the future, countries that produce and consume oil, natural gas and other energy sources should promote constructive talks for sound market development. The dialogue between the IEA and OPEC through the International Energy Forum should be furthered. To facilitate communications between energy consuming countries, the IEA should enhance cooperation with China and India that will increase oil imports in the future.

Part IV

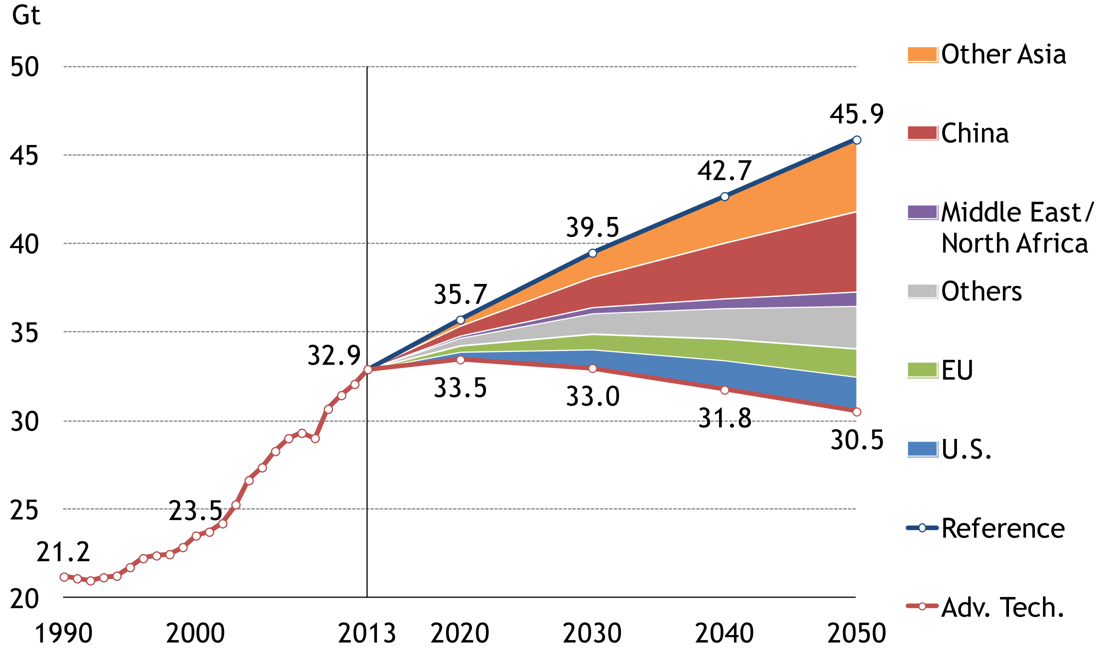
Analysing transition towards low-carbon while addressing climate change

8. CO_2 emission outlook and assessment of national GHG emission reduction targets

8.1 Energy-related CO_2 emissions in the Advanced Technologies Scenario

The further development of energy conservation and decarbonisation technologies will help reduce global CO_2 emissions from 2020 and post a decline of 2.4 Gt from 2013 to 2050 (Figure 100). An emission reduction of 15.4 Gt from the *Reference Scenario* in 2050 will exceed Asia's current emissions. The cumulative reductions through 2050 will reach 278 Gt, 8.5 times as much as current global emissions.

Figure 100 Global CO_2 emissions reduction by region [Advanced Technologies Scenario]

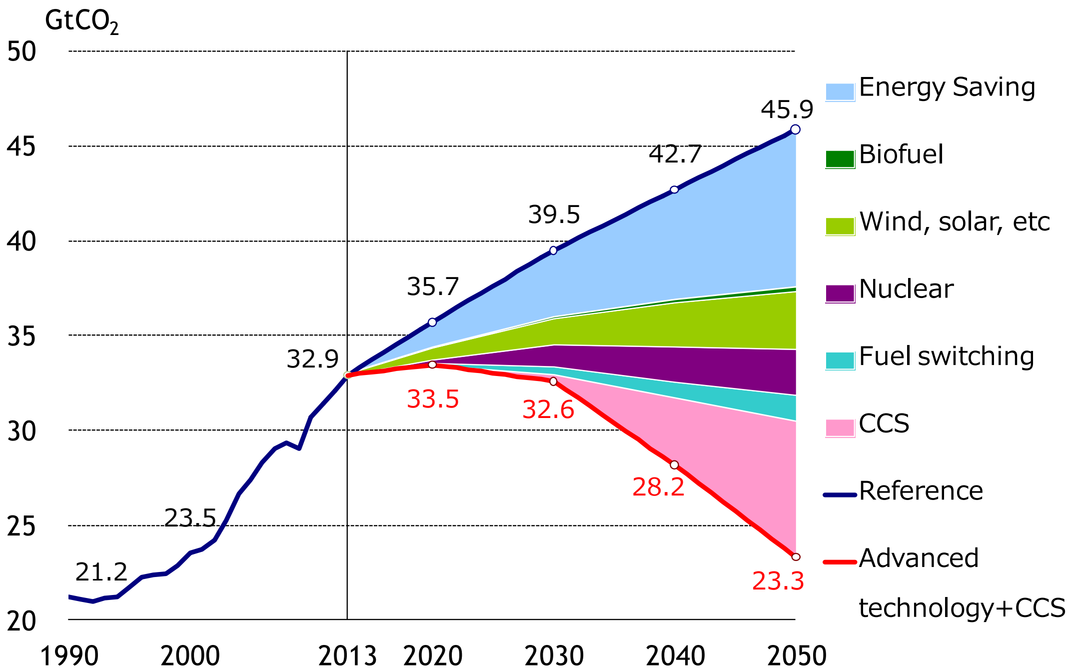


Of global CO_2 emission cuts in 2050, non-OECD countries will account for about 70%. China, the largest CO_2 emitter in the world, will reduce CO_2 emissions by 4.5 Gt, some three times as much as Japan's current emissions, and capture 53% of the Asian contribution. In order for China and other non-OECD countries to substantially reduce CO_2 emission, developed countries' decarbonisation technology assistance (technology transfer, institutional development, etc.) will be very important.

Of the global CO_2 emission reduction from the *Reference Scenario* to the *Advanced Technologies Scenario* in 2050, energy conservation will account for the largest share at 8.3 Gt, renewables will be second at 3.3 Gt, nuclear at 2.4 Gt and fuel switching at 1.4 Gt (Figure 101). CO_2 capture and storage (CCS) will account for 7.2 Gt mainly in the power generation sector. But CCS technology, unlike other means including energy conservation, does not positively impact the energy supply. It is important to look for various options without excessively focusing on certain technologies or means, taking into account not only the advantages of each technology or means but also the relevant risks.

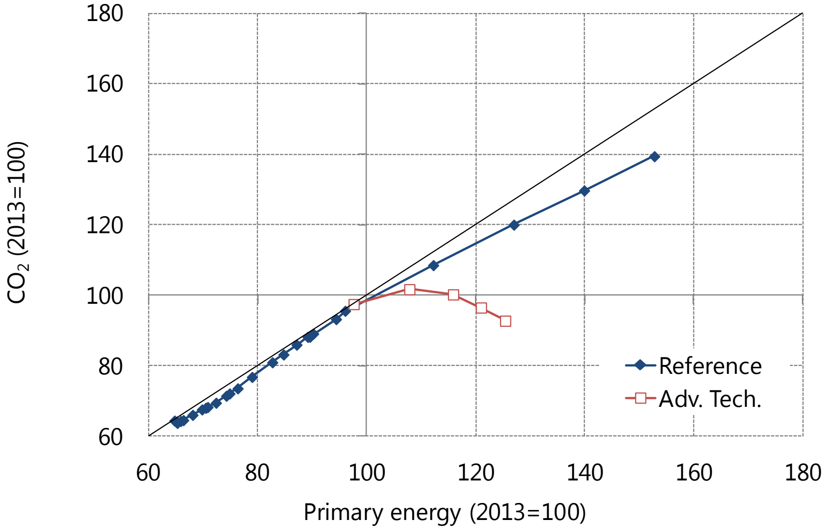
Figure 101 Global CO_2 emissions reduction by technology

[Advanced Technologies Scenario +CCS]



From the viewpoint of the carbon content of primary energy consumption, energy conservation technologies assumed for the *Advanced Technologies Scenario* may lead the world to reduce energy-related CO_2 emissions. CO_2 emission growth in the *Advanced Technologies Scenario* will be far slower than primary energy consumption growth and will turn negative despite energy consumption growth from 2020 (Figure 102). In the *Reference Scenario*, the spread of nuclear and renewable energy will lead CO_2 emission growth to slip only slightly below primary energy consumption growth. This means that the current energy policy promotion pace may fall short of bringing about any low-carbon society to the world.

Figure 102 Global primary energy consumption and CO_2 emissions [1990-2013, 2020, 2030, 2040, 2050]



Amid the growing recognition that GHG emissions must be substantially reduced to counter climate change, not only developed countries but also emerging countries have set voluntary medium-term GHG emission reduction targets in preparation for the 21st Conference of Parties to the United Nations Framework Convention on Climate Change, known as COP21, in December 2015. At COP21, a legal framework in which all countries will participate will take effect, requiring them to comply with the framework. From a long-term viewpoint, the world and individual countries could realize a bottom-up approach without concentrating on a single measure by building a GHG emission reduction framework, as seen in the *Advanced Technologies Scenario*. But we must test whether these voluntary targets would be as ambitious as in the *Advanced Technologies Scenario.*

Among primary energy sources, coal will undergo the greatest change from the *Reference Scenario* to the *Advanced Technologies Scenario* due to energy conservation, power generation efficiency improvements and fuel switching. Asia, including China and India, that is expected to continue to experience economic growth, will remain dependent on coal. CCS and other coal-related technology innovations will be important along with frameworks to support OECD countries' technology transfer to non-OECD countries, sectoral approaches and other global measures.

Even if each country sets ambitious CO_2 emission reduction targets and achieve them, CO_2 emissions in 2050 will still be higher than in 1990. The world will fall far short of halving CO_2 emissions by 2050. Unless dramatic technology innovations that are now considered as difficult are realized, the world will have difficulties halving 2013 CO_2 emissions by 2050. Not only climate change mitigation measures but also adaptation measures should be taken to effectively address climate change. Therefore, any analysis on climate change should be based on climate change damage and adaptation measures. The relationship between the GHG concentration and temperature rise should be further clarified for setting more realistic GHG emission reduction targets.

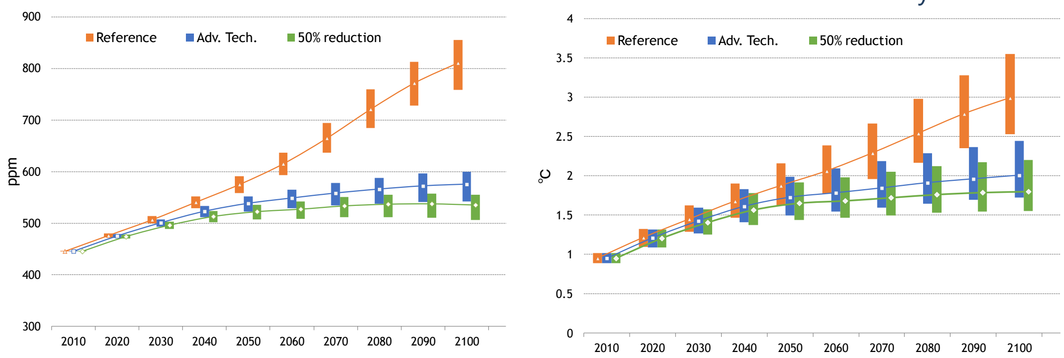
8.2 Extra-long-term CO_2 equivalent concentration and temperature increase

In Figure 103, the atmospheric CO_2 equivalent concentration[12] and a temperature rise from the 1850-1900 average are projected for the *Reference* and *Advanced Technologies Scenarios* extended through 2100 and for the 2050 halving scenario in which global CO_2 emissions will be halved from 2013 to 2050 and reduced to zero in 2100. Projection concentration ranges were estimated with the MAGICC model[13].

In the *Reference Scenario*, the atmospheric CO_2 equivalent concentration will reach 811 ppm of CO_2 equivalent (760-860 ppm) in 2100 and continue rising later. In the 2050 halving scenario, the concentration will stand at 535 ppm in 2100 and will remain stable in a 500-550 ppm range[14] later. While the temperature is projected to increase by 2.5-3.6°C from the latter half of the 19th century to 2100 in the *Reference Scenario*, the temperature rise will be limited to 1.5°-2.2°C, below 2.5°, with a probability to slip below 2°C in the 2050 halving scenario. The concentration in the *Advanced Technologies Scenario + CCS* in 2100 will be 575 ppm of CO_2 equivalent (540-600 ppm), relatively close to the projection in the 2050 halving scenario, with the temperature rise also being close. Given this projection, adaptation measures can be combined with mitigation measures into an option close to the 2050 halving scenario. As mitigation costs to achieve a projected CO_2 emission cut in the *Advanced Technology Scenario* or a higher target are substantial, the assessment of adaptation costs is important.

Figure 103 CO_2-eq. concentration and temperature rise

CO_2-equivalent concentration | Temperature rise from the latter half of the 19th century



Note: 17th-83rd percentiles

[12] The "CO_2-equivalent concentration" includes the forcing of all GHGs, as well as aerosols and albedo change.

[13] Meinshausen, M., S. C. B. Raper and T. M. L. Wigley (2011). "Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6: Part I – Model Description and Calibration." Atmospheric Chemistry and Physics 11: 1417-1456. doi:10.5194/acp-11-1417-2011.

[14] In order to cut the CO_2 equivalent concentration to 450 ppm by 2100, GHG emissions will have to be more than halved by 2050 and become negative later.

8.3 Assessing total national emission reduction targets

In the following, we are assessing the effectiveness of the CO_2 emission reduction targets proposed by the Intended Nationally Determined Contributions (INDCs)[15]. We projected global emissions in 2030 based on INDCs submitted by eight major economies (China, the United States, the European Union, India, Russia, Indonesia, Brazil and Japan) for comparison with emissions in the *Reference* and *Advanced Technologies Scenarios*. The eight major economies covered 65% of global GHG emissions totalling 49.8 Gt in 2010.

Comparing emission reduction targets

The eight major economies' INDCs are summarized into Table 16. INDCs provide three types of targets -- target emissions compared with base years, target emissions per GDP compared with base years and target emissions compared with a BAU (business as usual) level.

Table 16 INDCs of 8 major parties

Party	Date of submission	Target type	Reduction target	Base year	Target year	Coverage
EU	Mar 6	Absolute emissions	40%	1990	2030	GHG
United States	Mar 31	Absolute emissions	26～28%	2005	2025	GHG including LULUCF
Russia	Apr 1	Absolute emissions	25～30%	1990	2030	GHG
China	Jun 30	GDP intensity	60～65%	2005	2030	CO_2
Japan	Jul 17	Absolute emissions	26%	2013	2030	GHG
Indonesia	Sep 24	Reduction from BAU	29%	BAU	2030	GHG
Brazil	Sep 30	Absolute emissions	37% (43% for 2030)	2005	2025	GHG
India	Oct 1	GDP intensity	33～35%	2005	2030	GHG

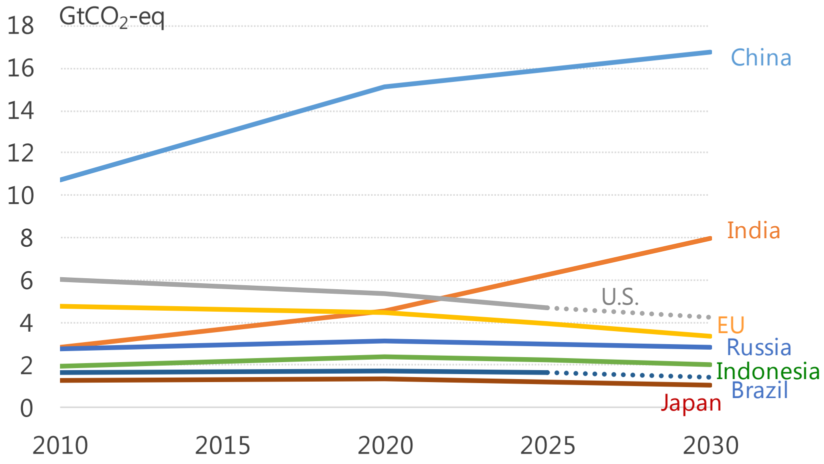
International comparison of GHG emissions

Figure 104 indicates global GHG emissions projected[16] for 2025 and 2030 based on the above INDCs.

[15] The Intended Nationally Determined Contribution (INDC) is a country's draft contribution providing commitments or targets. At the COP19 meeting in 2013, all parties to the United Nations Framework Convention on Climate Change were urged to notify the United Nations of their INDCs well before the 2015 COP21 meeting in Paris. At the 2014 COP20 meeting, an effective deadline for the notification was set for October 1, 2015. By this deadline, 117 countries and regions (144 countries) had submitted INDCs.

[16] As for emissions in base years and 2010, we used national inventory reports for developed countries and GHG or CO_2 emissions in the IEA's "CO_2 Emissions from Fuel Combustion 2014" for developing countries. For countries setting target emissions per GDP compared with base years, we used this Outlook's GDP projections. For countries submitting target emissions compared with BAU levels, we used BAU levels specified in INDCs.
China's CO_2 emissions were converted into GHG emissions based on the ratio of CO_2 emissions to GHG

Figure 104 GHG emission paths based on the INDCs



China will expand GHG emissions by 56% from 10.8 Gt in 2010 to 16.8 Gt in 2030. India will increase them 2.8-fold from 2.8 Gt in 2010 to 8.0 Gt in 2030, outdoing the United States and the European Union. The United States will cut GHG emissions from 6.0 Gt in 2010 to 4.3 Gt in 2030. The European Union will also reduce them from 4.8 Gt in 2010 to 3.4 Gt in 2030.

Comparing total INDCs with Reference and Advanced Technology Scenarios

Figure 105 compares total emissions under the INDCs with those in the *Reference* and *Advanced Technologies Scenarios*[17]. The IEA's INDC Scenario and Bridge Scenario[18] are also shown in the chart.

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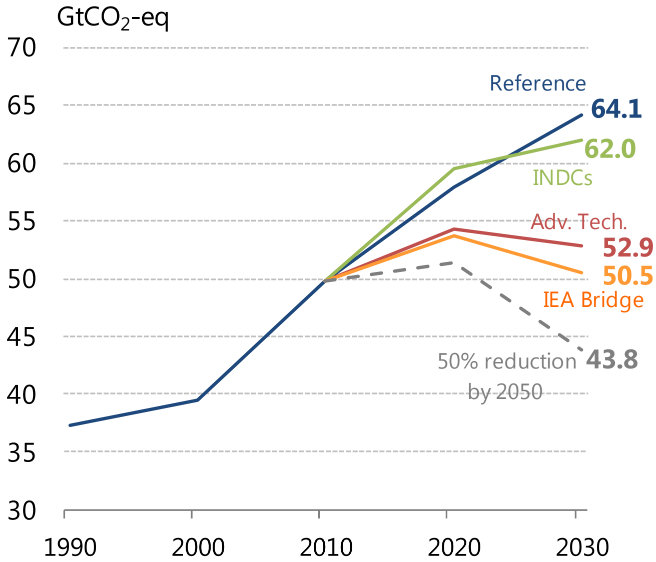
emissions in 2010 in the IEA's "CO_2 Emissions from Fuel Combustion 2014." For the United States, the 2005-2025 trends were extrapolated through 2030.
The emission levels in 2020 were based on the Cancun Pledge.

[17] In the INDC Scenario, we converted the eight major economies' emissions into global emissions based on the ratio of their emissions to global emissions in 2010 in the IEA's "CO_2 Emissions from Fuel Combustion 2014." Similarly, we converted energy-related CO_2 emissions in the *Reference* and *Advanced Technologies Scenarios* and the IEA scenario into GHG emissions based on the ratio of CO_2 emissions through fuel combustion to GHG emissions in 2010 in the IEA's "CO_2 Emissions from Fuel Combustion 2014."

[18] The IEA Bridge Scenario was announced in "Energy and Climate Change," a special report for the IEA's Energy Outlook 2015 published in June 2015. It deepens the IEA's INDC scenario, providing a GHG emission reduction scenario using five key policy measures – energy conservation, fossil-fuel subsidy reform, renewable energy technology investment, reducing the least-efficient coal-fired power plants and reducing upstream methane emissions.
The five policy pillars are:
- Increasing *energy efficiency*
- Reducing the use of the *least-efficient coal-fired power plants* and banning their construction
- Increasing investment in *renewable energy technologies* in the power sector from $270 billion in 2014 to $400 billion in 2030
- Gradual phasing out of *fossil-fuel subsidies* to end-users by 2030
- Reducing *methane emissions* in oil and gas production

The Bridge Scenario is based only on existing technologies and policy measures and lowers the

Figure 105 Comparison of GHG emission paths



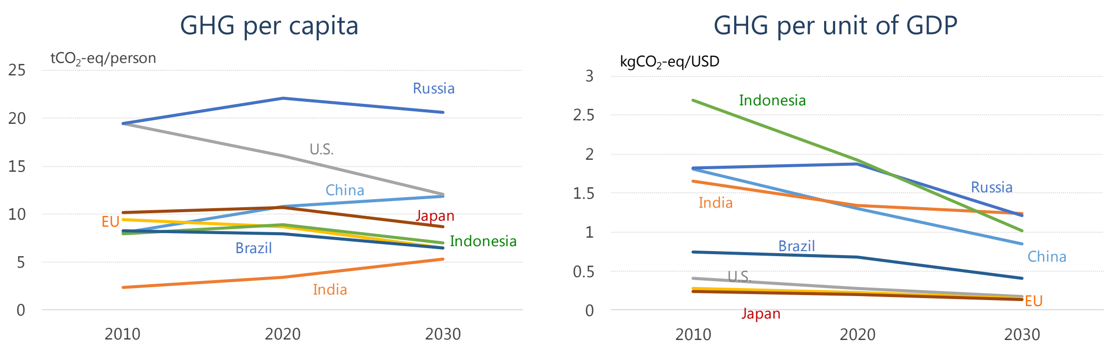
Global GHG emissions in 2030, projected with the major economies' INDCs, are closer to those in the *Reference Scenario* than those in the *Advanced Technologies Scenario*. The projected emissions post an increase, indicating a wide gap with the *Advanced Technologies Scenario.*

8.4 Assessing national emission reduction targets

International comparison of per capita GHG emissions and GHG emissions per GDP

Regarding national GHG emission reduction targets, we first conducted international comparison of per capita GHG emissions and GHG emissions per GDP.

Figure 106 GHG emissions per capita and per unit of GDP



Per capita GHG emissions will decline in the United States and increase in China through 2030. As a result, per capita GHG emissions in the United States will remarkably match those

application standard for these policies for a case in which these measures affect economic growth or access to modern energy services in developing countries.

in China in 2030. Those in India will post an increase while remaining low. Among developed countries, Japan will post the second lowest per capita GHG emissions after the European Union.

GHG emissions per GDP will decrease both in China and India. India's decrease will be slower than China's. Japan will keep its GHG emissions per GDP lower than in the European Union or the United States through 2030.

National INDC emission levels and Reference and Advanced Technologies Scenarios

Figure 107 compares national INDC emission levels with the *Reference* and *Advanced Technologies Scenarios*[19, 20].

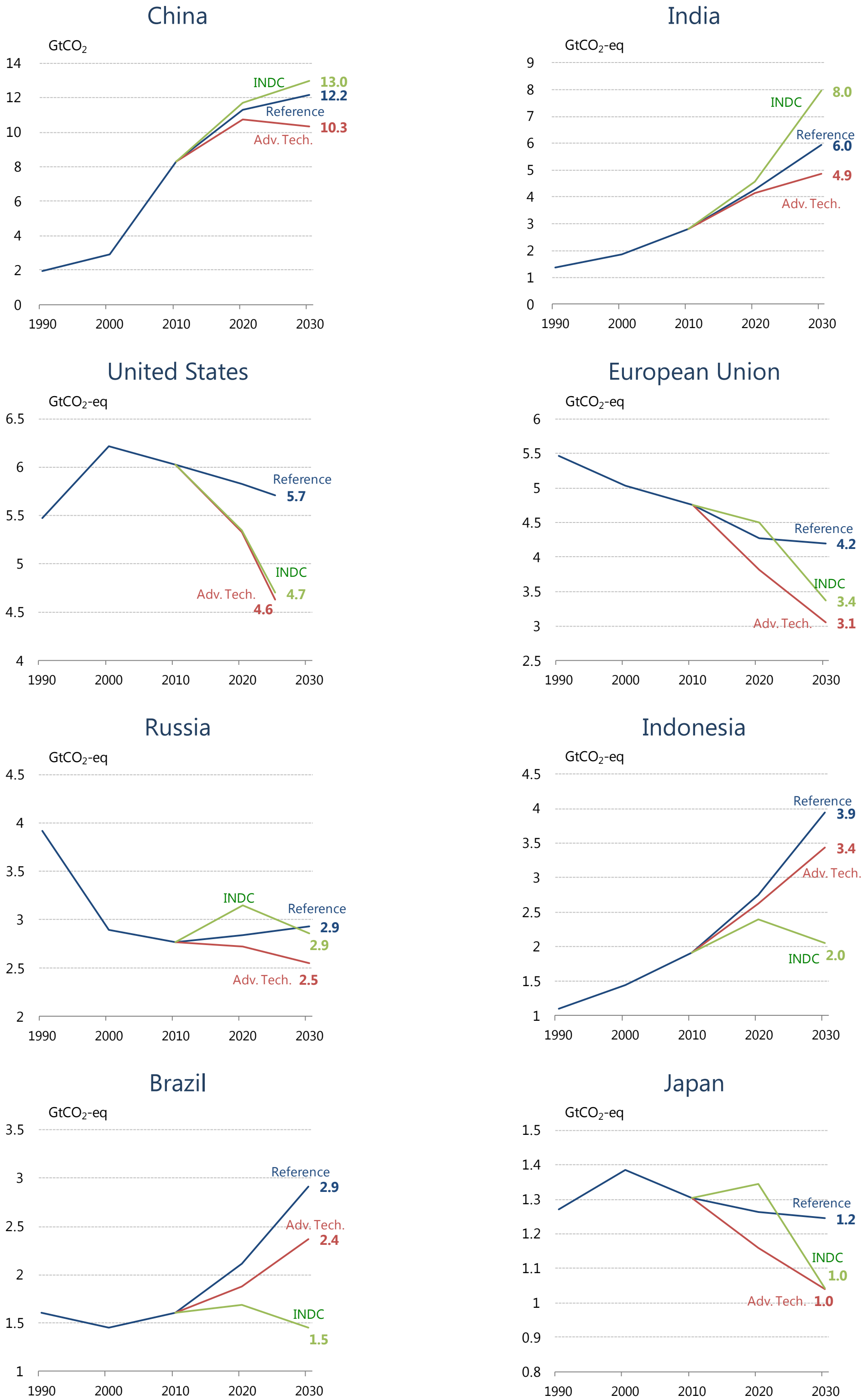
Emissions will exceed those in the *Reference Scenario* for India and match those in the scenario for China and Russia. European Union emissions will be positioned between those in the *Reference* and *Advanced Technologies Scenarios.* U.S. and Japanese emissions will be at their respective levels in the *Advanced Technologies Scenario*. Indonesia and Brazil will reduce emissions to levels less than in the *Advanced Technologies Scenario.* This may be because these countries project very high levels of emission reductions from current deforestation and forest degradation.

All these economies will be required to make as much effort as projected in the *Advanced Technologies Scenario.* In this respect, technology transfer to developing countries will be important.

[19] As for China, we used CO_2 emissions for comparison. We converted energy-related CO_2 emissions in the *Reference* and *Advanced Technologies Scenarios* into CO_2 emissions with the ratio of CO_2 emissions from fuel combustion to CO_2 emissions in 2010 in the IEA's "CO_2 Emissions from Fuel Combustion 2014."

[20] Japan's target for 2020 excludes emission cuts through nuclear energy.

Figure 107 INDCs compared with the Reference and Advanced Technologies Scenarios



9. CO_2 emission reduction measures and addressing climate change problem

9.1 Mitigation and adaptation costs and climate change damage

Due costs are usually required to restrict (mitigate) climate change through the reduction of GHG emissions. From current levels, costs for reducing emissions are to some extent relatively low and energy cost cuts through energy conservation may even result in some benefits. But beyond a certain point, costs may remarkably increase for spreading higher-cost energy-saving equipment to substantially reduce GHG emissions.

If the atmospheric GHG concentration increases due to insufficient mitigation, the resulting increase in the global average temperature would be associated with various phenomena like sea level rise, farm-affecting drought and new disease epidemics. To minimize their impacts on human lives, adaptation measures such as river and coastal embankments, reservoirs, agricultural research, and disease prevention and treatment are required. If these measures fail to reduce the impacts sufficiently, humans may sustain actual climate change damage.

"Mitigation" can trade off with "adaptation and damage." If mitigation is implemented at high cost, the need for adaptation or damage may decline. If mitigation fails to be implemented, higher damage costs may arise in the future. It is worthy of attention to note that the three not only have such a trade-off relationship but also a time relationship. This means that the implementation of mitigation measures at present or in the near future may directly influence the presence or absence of climate change damage in the future.

Models to project climate change damage and adaptation costs

A limited number of models have been published to project climate change damage and adaptation costs.

Climate change damage

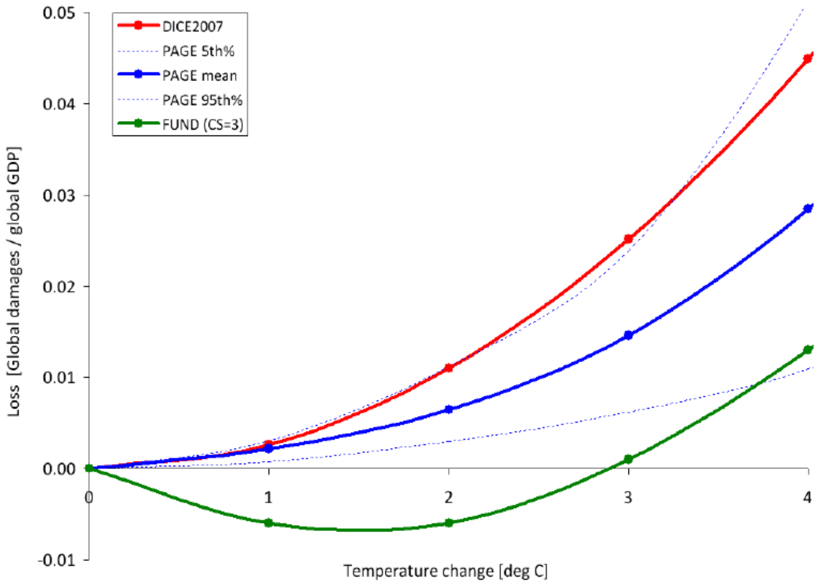
In 2010, the U.S. Interagency Working Group on Social Cost of Carbon compared climate change damage projections based on three comprehensive assessment models in its report titled "Social Cost of Carbon for Regulatory Impact Analysis[21]". The three models were – FUND (Climate Framework for Uncertainty, Negotiation and Distribution), DICE (Dynamic Integrated Climate-Economy) and PAGE (Policy Analysis of the Greenhouse Effect). The Social Cost of Carbon (SCC) is a projected monetary value of damage accompanying an increase in CO_2 emissions. The three comprehensive assessment models convert emissions into a change in the atmospheric concentration, the concentration into a temperature change and the temperature change into economic damage.

The abovementioned report noted that functions indicating impacts of climate change on consumption values of market and non-market goods are not accurate. Pointing out that no better approach could be found as far as data are concerned; the report provided an analysis

[21] Interagency Working Group on Social Cost of Carbon, US Government, 2010, "Social Cost of Carbon for Regulatory Impact Analysis" Updated in 2013

based on the three comprehensive assessment models. Damage functions for the three comprehensive assessment models, as shown in Figure 108, differ widely from each other. Given the difference, the report calls for reviewing damage functions or how adaptation, technological changes and catastrophic damage should be incorporated into the models.

Figure 108 Annual loss estimation by DICE, FUND and PAGE models



Source: Interagency Working Group on Social Cost of Carbon (2010)

Adaptation costs

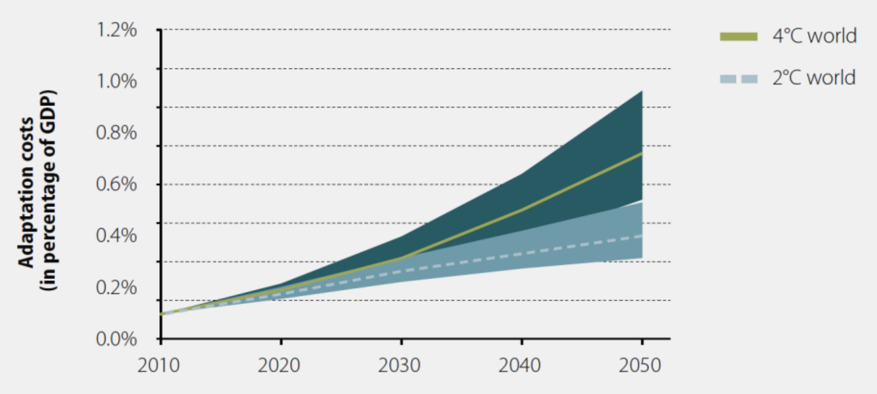
As for adaptation costs, the United Nations Environment Programme, in its document titled "The Adaptation Gap Report[22]" in 2014, provided new projections made with the AD-RICE (Adaptation-Regional Integrated model of Climate and the Economy) comprehensive assessment model while indicating adaptation cost estimates introduced earlier. The AD-RICE model extends the RICE model (modifying the global DICE model into a 12-region model) to include adaptation[23].

Figure 109 shows adaptation cost as a percentage of developing country GDP for the 2°C and the 4°C scenarios. Uncertainties are indicated within a 16-84 percentile range up and down from a central value. Adaptation costs in the high-emission scenario will rise rapidly over time. The costs in 2050 in the 4°C scenario are double those in the 2°C scenario.

[22] UNEP (2014), "The Adaptation Gap Report".

[23] K. de Bruin et al. (2009), "AD-DICE: an implementation of adaptation in the DICE model", Climate Change, 95, pp.63-81.

Figure 109 Estimated adaptation costs for 2°C and 4°C temperature rise



Note: 16th to 84th percentiles.
Source: UNEP (2014)

Projecting mitigation and adaptation costs and damage

In this section, we project and compare mitigation and adaptation costs and damage at different points in time. For "damage and adaptation costs," we used the equation in the DICE-2013E model[24]. For example, climate change damage in 2100 will depend not only on the CO_2 (or GHG for a more general case) emission reduction rate in 2100 but also on an emission reduction path through 2100. As described in Chapter 8, energy-related CO_2 emissions will increase from 32.9 Gt in 2013 to 45.9 Gt in 2050 in the *Reference Scenario*. If this trend continues further, CO_2 emissions will continue to increase over a longer term. In the *Advanced Technologies Scenario + CCS*, meanwhile, CO_2 emissions in 2050 will stand at 23.3 Gt, 49% less than in the *Reference Scenario* and 29% less than in 2013. Here, we make the projection according to paths indicated in Figure 110 for these scenarios extended through 2100 and the 2050 halving scenario in which global CO_2 emissions will be halved from 2013 in 2050 and cut to zero in 2100. We use our estimates for mitigation costs and assume an annual cost drop through technological advancement after 2050 at 0.5% in line with the DICE model.

[24] W. Nordhaus and P. Sztorc, "DICE 2013R: Introduction and User's Manual", http://www.econ.yale.edu/~nordhaus/homepage/documents/DICE_Manual_103113r2.pdf

Figure 110 Assumed CO_2 mitigation paths

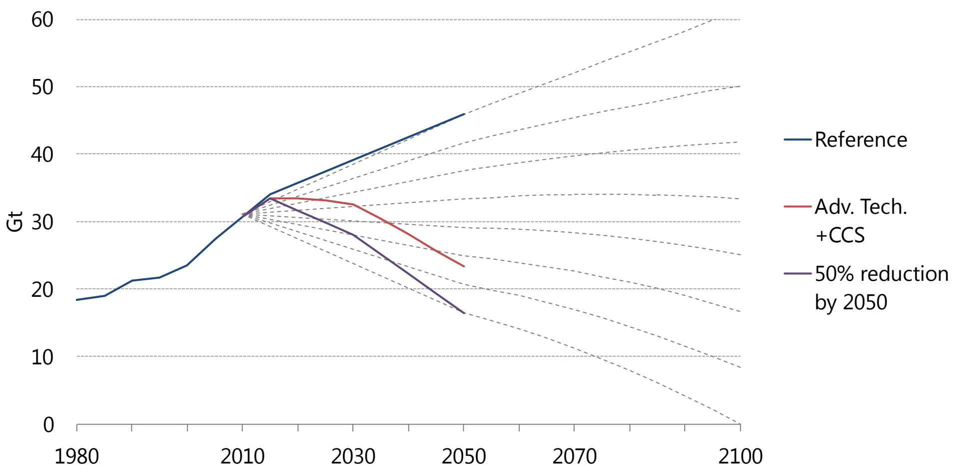
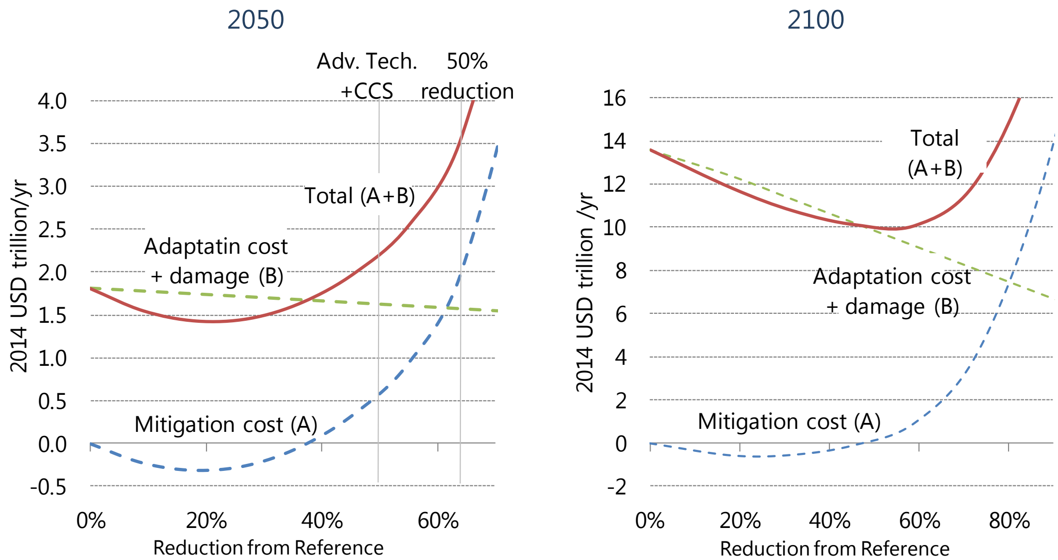


Figure 111 shows estimates for mitigation costs, and damage and adaptation costs in 2050 and 2100. The global average temperature gap between the Reference Scenario and the 2050 halving scenario will be limited to 0.1-0.2°C so that the damage and adaptation cost gap will be relatively small. Meanwhile, mitigation costs will be negative as an energy cost drop accompanying energy conservation for a certain degree of emission cuts from the *Reference Scenario* exceeds additional costs. As CO_2 emission cuts deepen, mitigation costs will increase gradually. Costs will increase rapidly as energy conservation measures beyond the *Advanced Technologies Scenario* + CCS are taken. In or after 2100, meanwhile, the impact of damage will remarkably increase. In the relatively near future, the impact of a mitigation cost change on total costs will be greater. Although the uncertainties accompanying the projection of these costs remain very high, it is safe to say that the impact of damage and adaptation costs will grow relatively greater in the far future. The total of mitigation and adaptation costs and damage may be minimized at some point between the *Reference Scenario* and the 2050 halving scenario. As mitigation costs and damage and adaptation costs have a trade-off relationship, it is impossible to simultaneously minimize the three. It is realistic to balance the three while taking into account minimization of the total costs.

Figure 111 Mitigation, adaptation costs and damage



Note: Adaptation cost and damage: Estimated using the equations in the DICE2013R model.
Mitigation cost: IEEJ estimate.
Equilibrium Climate Sensitivity: Assumed at 3°C.

9.2 Very long-term CO_2 emission reduction scenario

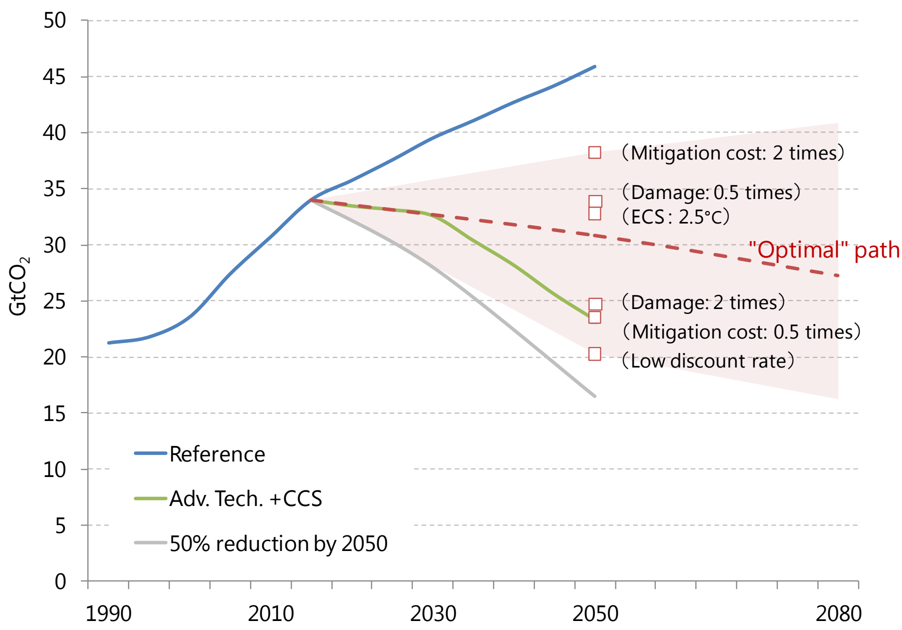
Mitigation costs, damage and adaptation costs, and emission reduction scenario

While damage and adaptation costs can be assessed, the results remain very uncertain. In contrast, many attempts to project mitigation costs have traditionally been made, so their assessment can be viewed as more realistic. Nevertheless, the assessment includes great uncertainties. Recognizing the uncertainties sufficiently, we here attempt to assess an emission path to minimize mitigation and adaptation costs and damage as described in Section 9-1.

The dotted line in Figure 111 indicates a long-term emission path to minimize the total accumulation of mitigation costs, damage and adaptation costs (more precisely, to maximize the cumulative utility corresponding to consumption affected by these costs). The path shows that global CO_2 emissions will gradually decline from the present to a greater level than in the *Advanced Technologies Scenario + CCS* in 2050. But the path may differ depending on mitigation cost and damage assumptions. If mitigation costs are assumed to be higher, the path will indicate greater CO_2 emissions. If damage is assumed to be higher, the path will indicate less CO_2 emissions.

If the Equilibrium Climate Sensitivity (ECS) is assumed at 2.5°C instead of 3.0°C, the path will indicate greater emissions. If the discount rate (see Box 4) is lower, emissions in 2050 will slip slightly below those in the *Advanced Technologies Scenario + CCS*. In this way, the optimum emission path widely differs depending on assumptions. Even if mitigation costs and damage are determined at accurate levels, the path cannot be determined uniquely. At least, however, estimates given in Figure 112 indicate that the case in which the world would fail to halve emissions by 2050 and pursue greater emission cuts later would still be more economically rational closer to the optimal path.

Figure 112 Evaluation of the optimal long-term emissions path



Box 4: How to assume the discount rate

When considering the problem of climate change, as well as other energy-related economic issues, we must take into account the time when the costs occur. Costs at different times have different values. Even if the effect of inflation is excluded, the future monetary value of an amount will be generally lower than the present value of the same amount. For example, if an interest income of 3% is expected, the value of $1,000 at present will become $1,340 in 10 years. Conversely, $1,000 10 years from now will have a present value of only $740. Therefore, the so-called discount rate (rate of change in the value of the same amount from a year to the next one, corresponding to the above real interest rate of 3%) is usually used to discount an amount. If mitigation and adaptation costs and damage in Figure 111 are used for assessment using a higher discount rate (the far future value is assessed as lower), the impact of climate change damage will become relatively smaller, indicating a path without mitigation measures as closer to an optimum path. If a lower discount rate is used, future damage will be assessed as higher, indicating a path for early mitigation as closer to an optimum one.

What discount rate should be used for considering very long-term problems such as climate change has been a controversial issue. The discount rate (social discount rate) ρ is usually given by the following equation called the Ramsey rule:

$$\rho = \delta + \eta g \quad (1)$$

Here, δ indicates the pure time preference rate. If this numeral is higher, people may view the future value as lower than at present. g is the consumption growth rate. Generally, consumption grows along with the economic size. η is the elasticity of marginal utility of consumption, indicating the percentage rate at which the value of an amount drops in response to a 1% expansion in consumption per capita.

Stern[25] gave priority to the equity between generations and assumed a low discount rate, setting δ at 0.1% and η at 1.0. Meanwhile, Nordhaus set δ and η to allow the present discount rate to match the real interest rate (slightly more than 5% per annum) actually observed in the United States (as indicated by Equation (1), the discount rate will fall as the economic size or consumption growth decelerates). The DICE-2013R model by Nordhaus uses 1.5% for δ and 1.45 for η. In this way, experts have different views on the discount rate assumption and assert their respective positions. The impact of these differences is very great as shown in Figure 112.

Actually, people usually use interest rates as discount rates for discounting computation at least for a period of several or dozens of years, as seen in the abovementioned case of $1,000. In this sense, adopting Stern's assumption is expected to mean deviating from realities. But recent researches have pointed out that lower discount rates will be appropriate if great uncertainties are expected in the long future or if the substitution of goods (e.g., the substitution of artificial goods for environmental goods) is difficult. Our projection accords with the parameter setting by Nordhaus for a standard case and uses Stern's discount rate for a lower-discount rate case.

Toward a long-term future

In this way, it is impossible to minimize mitigation costs, adaptation costs and damage simultaneously. It is realistic to restrict their total while balancing them. In this respect, it is important that even if the world fails to halve emissions by 2050, environmental damage or mitigation costs will cumulatively increase unless emissions are reduced further later as close to zero as possible.

Therefore, the world should seek a very ambitious GHG emission reduction over a longer term by promoting technical development to make energy conservation, decarbonisation, CO_2 absorption and other technologies available at low cost while pursuing the 500-550 ppm concentration close to the *Advanced Technologies Scenario*. Specifically, such ambitious GHG reduction will be difficult unless mitigation costs' rapid increase indicated in the area for large emission cuts in Figure 111 is dragged down. Over a medium to long term, the world should promote a cooperative approach to build worldwide networks linking country-by-country efforts to develop innovative technologies, including carbon capture and utilisation (CCU) – particularly, artificial photosynthesis –, next-generation nuclear power,

[25] N. Stern (2007), "The economics of climate change", Cambridge University Press.

space solar power systems and nuclear fusion. Furthermore, the world should develop and spread not only these energy supply side technologies but also innovative demand-side technologies that cannot be assumed now.

Table 17 Example of innovative technologies

Technology	Overview and challenges
Carbon Capture and Utilisation (CCU)	The technologies to capture and use carbon dioxide as industrial materials, etc. Large-scale processing of CO_2 is one of the major challenges.
Bioenergy and Carbon Capture and Storage (BECCS)	The technology to capture and store the carbon dioxide released by burning biofuels. If the biofuel can be regarded as carbon neutral, this technology makes it possible to achieve negative emissions. Barriers to large-scale deployment of BECCS include risks related to transport and provision of biomass feedstock.
Artificial photosynthesis	A chemical process to convert sunlight, water and carbon dioxide into carbohydrates and oxygen. As with the BECCS technology, it could realize negative emissions. Major challenges include the development of the catalysis to split water into hydrogen and oxygen.
Next generation nuclear power	Advanced nuclear technologies under development worldwide, including fast breeder reactors, high temperature gas-cooled reactors, molten salt reactors and small modular reactors.
Nuclear fusion	Unlike the conventional nuclear technologies that exploit the energy released by the fission of heavy nuclei, nuclear fusion makes use of the energy released during the reaction (fusion) of light nuclei. This technology could possibly result in an almost limitless supply of energy, without producing spent fuels as high-level radioactive wastes.
Space Solar Power System (SSPS)	A system that transmits energy from space-based solar power plants to the ground in the form of microwaves or laser beams. It can generate power stably with almost no influence from the weather. Reducing the costs of mass transition through space is one of the major challenges.

Annex

Table A18 Regional groupings

Asia	People's Republic of China		
	Hong Kong		
	India		
	Japan		
	Korea		
	Chinese Taipei		
	ASEAN	Brunei Darussalam	
		Indonesia	
		Malaysia	
		Myanmar	
		Philippines	
		Singapore	
		Thailand	
		Viet Nam	
	Others	Bangladesh, Cambodia, D. P. R. Korea, Mongolia, Nepal, Pakistan, Sri Lanka, and Other Asia in IEA statistics	
North America	United States		
	Canada		
Latin America	Brazil		
	Chile		
	Mexico		
	Others	Argentina, Bolivia, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Other Non–OECD Americas in IEA statistics	
Europe	OECD Europe	France	
		Germany	
		Italy	
		United Kingdom	
		Others	Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and Turkey
	Non-OECD Europe	Russia	
		Other non-OECD former Soviet Union	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan

	Others	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Gibraltar, Kosovo, Former Yugoslav Republic of Macedonia, Malta, Montenegro, Romania, and Serbia
Africa	Republic of South Africa	
	North Africa	Algeria, Egypt, Libya, Morocco, and Tunisia
	Others	Angola, Benin, Botswana, Cameroon, Democratic Republic of Congo, Congo, Côte d'Ivoire, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Mozambique, Namibia, Niger, Nigeria, Senegal, South Sudan, Sudan, Togo, United Republic of Tanzania, Zambia, Zimbabwe, and Other Africa in IEA statistics
Middle East	Iran	
	Iraq	
	Kuwait	
	Oman	
	Qatar	
	Saudi Arabia	
	United Arab Emirates	
	Others	Bahrain, Israel, Jordan, Lebanon, Syrian Arab Republic, and Yemen
Oceania	Australia	
	New Zealand	
International bunkers		
European Union	Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden, and the United Kingdom	
OECD	Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States	

Notes: (1) ASEAN includes neither Cambodia nor Lao P.D.R., (2) Other non-OECD former Soviet Union includes energy data of Estonia before 1990, and (3) OECD does not include Israel.

Table A19 Major energy and economic indicators

		1990	2013	2040 Reference	2040 Advanced Technologies	CAGR (%) 1990/2013	CAGR (%) 2013/2040 Reference	CAGR (%) 2013/2040 Advanced Technologies
Total primary energy consumption (Mtoe)	**World**	**8,768**	**13,555**	**18,963**	**16,396**	**1.9**	**1.3**	**0.7**
	Asia	2,110	5,409	8,691	7,534	4.2	1.8	1.2
	China	871	3,022	4,227	3,533	5.6	1.3	0.6
	India	307	775	1,830	1,582	4.1	3.2	2.7
	Japan	439	455	436	388	0.1	-0.2	-0.6
Oil consumption (Mtoe)	**World**	**3,232**	**4,210**	**5,496**	**4,658**	**1.2**	**1.0**	**0.4**
	Asia	618	1,254	2,053	1,778	3.1	1.8	1.3
	China	119	478	797	678	6.2	1.9	1.3
	India	61	176	451	396	4.7	3.5	3.0
	Japan	250	202	135	112	-0.9	-1.5	-2.2
Natural gas consumption (Mtoe)	**World**	**1,663**	**2,902**	**4,741**	**3,665**	**2.4**	**1.8**	**0.9**
	Asia	116	532	1,417	1,149	6.9	3.7	2.9
	China	13	140	580	491	11.0	5.4	4.8
	India	11	44	196	174	6.4	5.6	5.2
	Japan	44	106	112	72	3.9	0.2	-1.4
Coal consumption (Mtoe)	**World**	**2,221**	**3,928**	**4,577**	**3,105**	**2.5**	**0.6**	**-0.9**
	Asia	786	2,747	3,546	2,460	5.6	0.9	-0.4
	China	528	2,045	2,161	1,515	6.1	0.2	-1.1
	India	94	341	806	513	5.8	3.2	1.5
	Japan	77	121	116	95	2.0	-0.2	-0.9
Power generation (TWh)	**World**	**11,826**	**23,307**	**39,509**	**33,671**	**3.0**	**2.0**	**1.4**
	Asia	2,215	9,481	19,519	16,649	6.5	2.7	2.1
	China	621	5,422	9,728	8,224	9.9	2.2	1.6
	India	293	1,193	4,196	3,715	6.3	4.8	4.3
	Japan	836	1,038	1,200	1,015	0.9	0.5	-0.1
Energy-related carbon dioxide emissions (Mt)	**World**	**21,200**	**32,920**	**42,693**	**31,762**	**1.9**	**1.0**	**-0.1**
	Asia	4,920	14,936	21,966	16,195	4.9	1.4	0.3
	China	2,339	9,437	11,627	8,493	6.3	0.8	-0.4
	India	546	1,894	4,757	3,377	5.6	3.5	2.2
	Japan	1,070	1,234	1,034	791	0.6	-0.7	-1.6
Primary energy consumption per GDP (toe/$2010 million)	**World**	**234**	**192**	**125**	**108**	**-0.8**	**-1.6**	**-2.1**
	Asia	285	272	142	123	-0.2	-2.4	-2.9
	China	1,073	402	145	121	-4.2	-3.7	-4.3
	India	640	380	162	140	-2.2	-3.1	-3.6
	Japan	96	80	52	46	-0.8	-1.6	-2.0
Primary energy consumption per capita (toe/person)	**World**	**1.66**	**1.91**	**2.09**	**1.81**	**0.6**	**0.3**	**-0.2**
	Asia	0.72	1.39	1.90	1.65	2.9	1.2	0.6
	China	0.77	2.23	3.04	2.54	4.7	1.2	0.5
	India	0.35	0.62	1.14	0.99	2.5	2.3	1.8
	Japan	3.56	3.57	3.82	3.40	0.0	0.3	-0.2
GDP ($2010 billion)	**World**	**37,514**	**70,542**	**152,280**	**152,341**	**2.8**	**2.9**	**2.9**
	Asia	7,400	19,855	61,360	61,421	4.4	4.3	4.3
	China	811	7,513	29,180	29,180	10.2	5.2	5.2
	India	479	2,039	11,298	11,298	6.5	6.5	6.5
	Japan	4,553	5,656	8,369	8,429	0.9	1.5	1.5
Population (Million)	**World**	**5,271**	**7,114**	**9,068**	**9,068**	**1.3**	**0.9**	**0.9**
	Asia	2,931	3,890	4,579	4,579	1.2	0.6	0.6
	China	1,135	1,357	1,389	1,389	0.8	0.1	0.1
	India	869	1,252	1,599	1,599	1.6	0.9	0.9
	Japan	124	127	114	114	0.1	-0.4	-0.4

Table A20 Population

(Million)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	5,271 (100)	6,093 (100)	7,114 (100)	7,685 (100)	8,420 (100)	9,068 (100)	1.3	1.1	0.9	0.7	0.9
Asia	2,931 (55.6)	3,401 (55.8)	3,890 (54.7)	4,137 (53.8)	4,406 (52.3)	4,579 (50.5)	1.2	0.9	0.6	0.4	0.6
China	1,135 (21.5)	1,263 (20.7)	1,357 (19.1)	1,398 (18.2)	1,410 (16.7)	1,389 (15.3)	0.8	0.4	0.1	-0.1	0.1
India	869 (16.5)	1,042 (17.1)	1,252 (17.6)	1,359 (17.7)	1,495 (17.8)	1,599 (17.6)	1.6	1.2	1.0	0.7	0.9
Japan	124 (2.3)	127 (2.1)	127 (1.8)	125 (1.6)	120 (1.4)	114 (1.3)	0.1	-0.2	-0.4	-0.5	-0.4
Korea	43 (0.8)	47 (0.8)	50 (0.7)	52 (0.7)	53 (0.6)	53 (0.6)	0.7	0.4	0.2	0.0	0.2
Chinese Taipei	20 (0.4)	22 (0.4)	23 (0.3)	23 (0.3)	23 (0.3)	22 (0.2)	0.6	0.0	-0.1	-0.4	-0.2
ASEAN	427 (8.1)	503 (8.3)	594 (8.3)	640 (8.3)	693 (8.2)	732 (8.1)	1.4	1.1	0.8	0.5	0.8
Indonesia	179 (3.4)	209 (3.4)	250 (3.5)	270 (3.5)	294 (3.5)	311 (3.4)	1.5	1.1	0.8	0.6	0.8
Malaysia	18 (0.3)	23 (0.4)	30 (0.4)	33 (0.4)	36 (0.4)	39 (0.4)	2.2	1.4	1.1	0.7	1.0
Myanmar	42 (0.8)	48 (0.8)	53 (0.7)	57 (0.7)	61 (0.7)	63 (0.7)	1.0	0.9	0.7	0.4	0.6
Philippines	62 (1.2)	78 (1.3)	98 (1.4)	109 (1.4)	125 (1.5)	138 (1.5)	2.0	1.5	1.3	1.0	1.3
Singapore	3 (0.1)	4 (0.1)	5 (0.1)	6 (0.1)	6 (0.1)	7 (0.1)	2.5	1.5	0.7	0.4	0.8
Thailand	57 (1.1)	62 (1.0)	67 (0.9)	68 (0.9)	68 (0.8)	66 (0.7)	0.7	0.2	0.0	-0.3	-0.1
Viet Nam	66 (1.3)	78 (1.3)	90 (1.3)	96 (1.3)	103 (1.2)	108 (1.2)	1.3	1.0	0.7	0.4	0.7
Asia excl. Japan	2,808 (53.3)	3,274 (53.7)	3,762 (52.9)	4,012 (52.2)	4,285 (50.9)	4,465 (49.2)	1.3	0.9	0.7	0.4	0.6
North America	277 (5.3)	313 (5.1)	351 (4.9)	370 (4.8)	395 (4.7)	415 (4.6)	1.0	0.7	0.7	0.5	0.6
United States	250 (4.7)	282 (4.6)	316 (4.4)	332 (4.3)	355 (4.2)	373 (4.1)	1.0	0.7	0.6	0.5	0.6
Latin America	441 (8.4)	521 (8.6)	611 (8.6)	656 (8.5)	710 (8.4)	749 (8.3)	1.4	1.0	0.8	0.5	0.8
OECD Europe	499 (9.5)	521 (8.5)	557 (7.8)	570 (7.4)	580 (6.9)	585 (6.5)	0.5	0.3	0.2	0.1	0.2
European Union	478 (9.1)	488 (8.0)	507 (7.1)	516 (6.7)	523 (6.2)	526 (5.8)	0.3	0.3	0.1	0.0	0.1
Non-OECD Europe	344 (6.5)	341 (5.6)	342 (4.8)	347 (4.5)	347 (4.1)	342 (3.8)	0.0	0.2	0.0	-0.2	0.0
Africa	627 (11.9)	806 (13.2)	1,109 (15.6)	1,318 (17.2)	1,652 (19.6)	2,030 (22.4)	2.5	2.5	2.3	2.1	2.3
Middle East	132 (2.5)	166 (2.7)	226 (3.2)	256 (3.3)	296 (3.5)	332 (3.7)	2.4	1.8	1.5	1.1	1.4
Oceania	20 (0.4)	23 (0.4)	28 (0.4)	30 (0.4)	33 (0.4)	36 (0.4)	1.3	1.3	1.0	0.8	1.0
OECD	1,062 (20.2)	1,150 (18.9)	1,254 (17.6)	1,299 (16.9)	1,348 (16.0)	1,380 (15.2)	0.7	0.5	0.4	0.2	0.4
Non-OECD	4,209 (79.8)	4,943 (81.1)	5,860 (82.4)	6,386 (83.1)	7,071 (84.0)	7,688 (84.8)	1.4	1.2	1.0	0.8	1.0

Source: United Nations "Population Estimates and Projections: The 2012 Revision", World Bank "World Development Indicators"

Note: Figures in parentheses are global shares (%).

Table A21 GDP [Reference Scenario and Advanced Technologies Scenario]

($2010 billion)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	37,514 (100)	49,355 (100)	70,542 (100)	87,139 (100)	118,035 (100)	152,280 (100)	2.8	3.1	3.1	2.6	2.9
Asia	7,400 (19.7)	10,696 (21.7)	19,855 (28.1)	27,912 (32.0)	43,027 (36.5)	61,360 (40.3)	4.4	5.0	4.4	3.6	4.3
China	811 (2.2)	2,189 (4.4)	7,513 (10.7)	11,641 (13.4)	19,762 (16.7)	29,180 (19.2)	10.2	6.5	5.4	4.0	5.2
India	479 (1.3)	825 (1.7)	2,039 (2.9)	3,391 (3.9)	6,462 (5.5)	11,298 (7.4)	6.5	7.5	6.7	5.7	6.5
Japan	4,553 (12.1)	5,093 (10.3)	5,656 (8.0)	6,547 (7.5)	7,566 (6.4)	8,369 (5.5)	0.9	2.1	1.5	1.0	1.5
Korea	377 (1.0)	710 (1.4)	1,195 (1.7)	1,525 (1.7)	1,985 (1.7)	2,375 (1.6)	5.1	3.5	2.7	1.8	2.6
Chinese Taipei	167 (0.4)	305 (0.6)	482 (0.7)	636 (0.7)	790 (0.7)	900 (0.6)	4.7	4.0	2.2	1.3	2.3
ASEAN	703 (1.9)	1,137 (2.3)	2,190 (3.1)	3,097 (3.6)	4,848 (4.1)	7,019 (4.6)	5.1	5.1	4.6	3.8	4.4
Indonesia	282 (0.8)	426 (0.9)	849 (1.2)	1,247 (1.4)	2,015 (1.7)	3,041 (2.0)	4.9	5.6	4.9	4.2	4.8
Malaysia	79 (0.2)	158 (0.3)	288 (0.4)	408 (0.5)	633 (0.5)	872 (0.6)	5.8	5.1	4.5	3.3	4.2
Myanmar	7 (0.0)	13 (0.0)	51 (0.1)	87 (0.1)	156 (0.1)	248 (0.2)	9.2	8.0	6.0	4.8	6.1
Philippines	95 (0.3)	125 (0.3)	237 (0.3)	360 (0.4)	563 (0.5)	838 (0.6)	4.1	6.2	4.6	4.0	4.8
Singapore	68 (0.2)	134 (0.3)	267 (0.4)	331 (0.4)	436 (0.4)	499 (0.3)	6.2	3.1	2.8	1.4	2.3
Thailand	135 (0.4)	209 (0.4)	350 (0.5)	444 (0.5)	637 (0.5)	866 (0.6)	4.2	3.5	3.7	3.1	3.4
Viet Nam	29 (0.1)	61 (0.1)	137 (0.2)	205 (0.2)	388 (0.3)	631 (0.4)	6.9	6.0	6.6	5.0	5.8
Asia excl. Japan	2,847 (7.6)	5,603 (11.4)	14,198 (20.1)	21,366 (24.5)	35,461 (30.0)	52,992 (34.8)	7.2	6.0	5.2	4.1	5.0
North America	10,064 (26.8)	14,050 (28.5)	17,619 (25.0)	20,910 (24.0)	26,405 (22.4)	31,603 (20.8)	2.5	2.5	2.4	1.8	2.2
United States	9,056 (24.1)	12,713 (25.8)	15,902 (22.5)	18,932 (21.7)	23,986 (20.3)	28,725 (18.9)	2.5	2.5	2.4	1.8	2.2
Latin America	2,764 (7.4)	3,744 (7.6)	5,691 (8.1)	6,515 (7.5)	8,993 (7.6)	11,569 (7.6)	3.2	2.0	3.3	2.6	2.7
OECD Europe	12,611 (33.6)	15,826 (32.1)	18,688 (26.5)	21,167 (24.3)	24,766 (21.0)	27,948 (18.4)	1.7	1.8	1.6	1.2	1.5
European Union	11,862 (31.6)	14,721 (29.8)	17,159 (24.3)	19,411 (22.3)	22,767 (19.3)	25,759 (16.9)	1.6	1.8	1.6	1.2	1.5
Non-OECD Europe	2,168 (5.8)	1,509 (3.1)	2,705 (3.8)	2,958 (3.4)	4,019 (3.4)	5,121 (3.4)	1.0	1.3	3.1	2.5	2.4
Africa	886 (2.4)	1,145 (2.3)	2,117 (3.0)	2,924 (3.4)	4,566 (3.9)	6,928 (4.5)	3.9	4.7	4.6	4.3	4.5
Middle East	902 (2.4)	1,393 (2.8)	2,419 (3.4)	2,984 (3.4)	4,054 (3.4)	5,153 (3.4)	4.4	3.0	3.1	2.4	2.8
Oceania	719 (1.9)	993 (2.0)	1,447 (2.1)	1,769 (2.0)	2,206 (1.9)	2,598 (1.7)	3.1	2.9	2.2	1.7	2.2
OECD	29,024 (77.4)	37,701 (76.4)	46,008 (65.2)	53,678 (61.6)	65,412 (55.4)	76,233 (50.1)	2.0	2.2	2.0	1.5	1.9
Non-OECD	8,490 (22.6)	11,654 (23.6)	24,534 (34.8)	33,461 (38.4)	52,623 (44.6)	76,047 (49.9)	4.7	4.5	4.6	3.8	4.3

Source: World Bank "World Development Indicators", etc. (historical)

Note: Figures in parentheses are global shares (%).

Table A22 International energy prices

Real prices			2014	Reference 2020	Reference 2030	Reference 2040	Lower Price 2020	Lower Price 2030	Lower Price 2040
Crude oil		$2014/bbl	105	75	100	125	70	75	80
Natural gas	Japan	$2014/MBtu	16.3	10.7	12.8	14.1	9.6	9.8	10.2
	Europe (UK)	$2014/MBtu	8.2	8.5	9.8	11.7	6.8	7.3	8.1
	United States	$2014/MBtu	4.4	4.5	5.6	6.8	3.4	3.7	3.9
Steam coal		$2014/t	98	89	106	132	86	96	108

Nominal prices			2014	Reference 2020	Reference 2030	Reference 2040	Lower Price 2020	Lower Price 2030	Lower Price 2040
Crude oil		$/bbl	105	84	137	209	79	103	134
Natural gas	Japan	$/MBtu	16.3	12.0	17.6	23.6	10.8	13.5	17.1
	Europe (UK)	$/MBtu	8.2	9.6	13.5	19.6	7.7	10.0	13.6
	United States	$/MBtu	4.4	5.1	7.7	11.4	3.8	5.1	6.5
Steam coal		$/t	98	100	145	221	97	132	181

Note: 2% per annum of inflation rates are assumed.

Table A23 Primary energy consumption [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	**8,768** (100)	**10,057** (100)	**13,555** (100)	**15,207** (100)	**17,211** (100)	**18,963** (100)	1.9	1.7	1.2	1.0	1.3
Asia	**2,110** (24.1)	**2,920** (29.0)	**5,409** (39.9)	**6,411** (42.2)	**7,567** (44.0)	**8,691** (45.8)	4.2	2.5	1.7	1.4	1.8
China	**871** (9.9)	**1,161** (11.5)	**3,022** (22.3)	**3,498** (23.0)	**3,918** (22.8)	**4,227** (22.3)	5.6	2.1	1.1	0.8	1.3
India	**307** (3.5)	**441** (4.4)	**775** (5.7)	**993** (6.5)	**1,360** (7.9)	**1,830** (9.7)	4.1	3.6	3.2	3.0	3.2
Japan	**439** (5.0)	**519** (5.2)	**455** (3.4)	**471** (3.1)	**461** (2.7)	**436** (2.3)	0.1	0.5	-0.2	-0.6	-0.2
Korea	**93** (1.1)	**188** (1.9)	**264** (1.9)	**300** (2.0)	**328** (1.9)	**325** (1.7)	4.6	1.9	0.9	-0.1	0.8
Chinese Taipei	**48** (0.5)	**85** (0.8)	**109** (0.8)	**120** (0.8)	**126** (0.7)	**128** (0.7)	3.6	1.4	0.5	0.1	0.6
ASEAN	**233** (2.7)	**380** (3.8)	**587** (4.3)	**776** (5.1)	**1,035** (6.0)	**1,327** (7.0)	4.1	4.1	2.9	2.5	3.1
Indonesia	**99** (1.1)	**156** (1.5)	**214** (1.6)	**314** (2.1)	**419** (2.4)	**540** (2.8)	3.4	5.6	2.9	2.6	3.5
Malaysia	**22** (0.3)	**49** (0.5)	**89** (0.7)	**109** (0.7)	**135** (0.8)	**160** (0.8)	6.2	3.0	2.1	1.7	2.2
Myanmar	**11** (0.1)	**13** (0.1)	**17** (0.1)	**20** (0.1)	**26** (0.1)	**33** (0.2)	1.9	2.7	2.5	2.5	2.6
Philippines	**29** (0.3)	**40** (0.4)	**45** (0.3)	**58** (0.4)	**76** (0.4)	**99** (0.5)	1.9	3.7	2.8	2.6	3.0
Singapore	**12** (0.1)	**19** (0.2)	**26** (0.2)	**31** (0.2)	**37** (0.2)	**41** (0.2)	3.6	2.5	1.8	1.0	1.7
Thailand	**42** (0.5)	**72** (0.7)	**134** (1.0)	**159** (1.0)	**202** (1.2)	**244** (1.3)	5.2	2.4	2.5	1.9	2.2
Viet Nam	**18** (0.2)	**29** (0.3)	**60** (0.4)	**83** (0.5)	**136** (0.8)	**206** (1.1)	5.4	4.7	5.1	4.2	4.7
Asia excl. Japan	**1,670** (19.0)	**2,401** (23.9)	**4,955** (36.6)	**5,940** (39.1)	**7,106** (41.3)	**8,255** (43.5)	4.8	2.6	1.8	1.5	1.9
North America	**2,124** (24.2)	**2,525** (25.1)	**2,442** (18.0)	**2,519** (16.6)	**2,538** (14.7)	**2,463** (13.0)	0.6	0.4	0.1	-0.3	0.0
United States	**1,915** (21.8)	**2,273** (22.6)	**2,188** (16.1)	**2,254** (14.8)	**2,260** (13.1)	**2,181** (11.5)	0.6	0.4	0.0	-0.4	0.0
Latin America	**464** (5.3)	**594** (5.9)	**849** (6.3)	**964** (6.3)	**1,194** (6.9)	**1,381** (7.3)	2.7	1.8	2.2	1.5	1.8
OECD Europe	**1,620** (18.5)	**1,746** (17.4)	**1,737** (12.8)	**1,788** (11.8)	**1,807** (10.5)	**1,795** (9.5)	0.3	0.4	0.1	-0.1	0.1
European Union	**1,645** (18.8)	**1,692** (16.8)	**1,626** (12.0)	**1,674** (11.0)	**1,693** (9.8)	**1,682** (8.9)	-0.1	0.4	0.1	-0.1	0.1
Non-OECD Europe	**1,537** (17.5)	**1,003** (10.0)	**1,156** (8.5)	**1,185** (7.8)	**1,266** (7.4)	**1,323** (7.0)	-1.2	0.4	0.7	0.4	0.5
Africa	**391** (4.5)	**494** (4.9)	**747** (5.5)	**906** (6.0)	**1,134** (6.6)	**1,368** (7.2)	2.9	2.8	2.3	1.9	2.3
Middle East	**222** (2.5)	**374** (3.7)	**713** (5.3)	**837** (5.5)	**1,006** (5.8)	**1,160** (6.1)	5.2	2.3	1.9	1.4	1.8
Oceania	**99** (1.1)	**125** (1.2)	**149** (1.1)	**162** (1.1)	**169** (1.0)	**172** (0.9)	1.8	1.2	0.4	0.2	0.5
OECD	**4,511** (51.4)	**5,274** (52.4)	**5,276** (38.9)	**5,520** (36.3)	**5,627** (32.7)	**5,558** (29.3)	0.7	0.6	0.2	-0.1	0.2
Non-OECD	**4,055** (46.2)	**4,509** (44.8)	**7,925** (58.5)	**9,251** (60.8)	**11,055** (64.2)	**12,796** (67.5)	3.0	2.2	1.8	1.5	1.8

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). World includes international bunkers.

Table A24 Primary energy consumption, coal [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	**2,221** (100)	**2,343** (100)	**3,928** (100)	**4,143** (100)	**4,367** (100)	**4,577** (100)	2.5	0.8	0.5	0.5	0.6
Asia	**786** (35.4)	**1,063** (45.4)	**2,747** (69.9)	**2,992** (72.2)	**3,271** (74.9)	**3,546** (77.5)	5.6	1.2	0.9	0.8	0.9
China	**528** (23.8)	**691** (29.5)	**2,045** (52.1)	**2,157** (52.1)	**2,192** (50.2)	**2,161** (47.2)	6.1	0.8	0.2	-0.1	0.2
India	**94** (4.2)	**146** (6.2)	**341** (8.7)	**428** (10.3)	**584** (13.4)	**806** (17.6)	5.8	3.3	3.1	3.3	3.2
Japan	**77** (3.4)	**97** (4.1)	**121** (3.1)	**118** (2.8)	**121** (2.8)	**116** (2.5)	2.0	-0.4	0.2	-0.4	-0.2
Korea	**25** (1.1)	**42** (1.8)	**78** (2.0)	**80** (1.9)	**89** (2.0)	**86** (1.9)	5.0	0.5	1.1	-0.4	0.4
Chinese Taipei	**11** (0.5)	**30** (1.3)	**40** (1.0)	**40** (1.0)	**40** (0.9)	**39** (0.8)	5.7	-0.1	-0.1	-0.3	-0.2
ASEAN	**13** (0.6)	**32** (1.4)	**91** (2.3)	**131** (3.2)	**197** (4.5)	**280** (6.1)	9.0	5.2	4.2	3.6	4.2
Indonesia	**4** (0.2)	**12** (0.5)	**32** (0.8)	**54** (1.3)	**86** (2.0)	**126** (2.8)	10.0	8.0	4.8	3.9	5.3
Malaysia	**1** (0.1)	**2** (0.1)	**15** (0.4)	**20** (0.5)	**26** (0.6)	**32** (0.7)	11.1	3.6	2.7	2.1	2.7
Myanmar	**0** (0.0)	**0** (0.0)	**0** (0.0)	**1** (0.0)	**1** (0.0)	**2** (0.1)	7.7	10.5	6.7	5.0	7.0
Philippines	**2** (0.1)	**5** (0.2)	**11** (0.3)	**13** (0.3)	**19** (0.4)	**27** (0.6)	8.9	2.3	4.2	3.5	3.5
Singapore	**0** (0.0)	**-** (-)	**0** (0.0)	**0** (0.0)	**0** (0.0)	**0** (0.0)	11.5	3.6	2.5	1.2	2.3
Thailand	**4** (0.2)	**8** (0.3)	**17** (0.4)	**20** (0.5)	**25** (0.6)	**31** (0.7)	6.8	1.9	2.6	2.0	2.2
Viet Nam	**2** (0.1)	**4** (0.2)	**16** (0.4)	**23** (0.6)	**38** (0.9)	**61** (1.3)	8.9	5.8	5.0	4.8	5.2
Asia excl. Japan	**709** (31.9)	**966** (41.2)	**2,626** (66.9)	**2,874** (69.4)	**3,151** (72.1)	**3,430** (74.9)	5.9	1.3	0.9	0.9	1.0
North America	**485** (21.8)	**565** (24.1)	**450** (11.4)	**417** (10.1)	**345** (7.9)	**269** (5.9)	-0.3	-1.1	-1.9	-2.5	-1.9
United States	**460** (20.7)	**534** (22.8)	**432** (11.0)	**401** (9.7)	**334** (7.7)	**262** (5.7)	-0.3	-1.0	-1.8	-2.4	-1.8
Latin America	**20** (0.9)	**27** (1.2)	**43** (1.1)	**45** (1.1)	**60** (1.4)	**74** (1.6)	3.3	0.6	3.1	2.0	2.0
OECD Europe	**449** (20.2)	**330** (14.1)	**307** (7.8)	**294** (7.1)	**285** (6.5)	**265** (5.8)	-1.6	-0.6	-0.3	-0.7	-0.5
European Union	**456** (20.5)	**321** (13.7)	**286** (7.3)	**273** (6.6)	**266** (6.1)	**247** (5.4)	-2.0	-0.7	-0.3	-0.8	-0.5
Non-OECD Europe	**367** (16.5)	**209** (8.9)	**219** (5.6)	**210** (5.1)	**198** (4.5)	**192** (4.2)	-2.2	-0.7	-0.6	-0.3	-0.5
Africa	**74** (3.3)	**90** (3.8)	**104** (2.6)	**126** (3.0)	**144** (3.3)	**167** (3.6)	1.5	2.7	1.4	1.5	1.8
Middle East	**3** (0.1)	**8** (0.3)	**10** (0.3)	**12** (0.3)	**16** (0.4)	**21** (0.5)	5.4	2.9	2.8	2.6	2.7
Oceania	**36** (1.6)	**49** (2.1)	**47** (1.2)	**48** (1.2)	**47** (1.1)	**45** (1.0)	1.1	0.3	-0.2	-0.6	-0.2
OECD	**1,078** (48.5)	**1,094** (46.7)	**1,022** (26.0)	**978** (23.6)	**916** (21.0)	**818** (17.9)	-0.2	-0.6	-0.6	-1.1	-0.8
Non-OECD	**1,143** (51.5)	**1,248** (53.3)	**2,905** (74.0)	**3,165** (76.4)	**3,451** (79.0)	**3,759** (82.1)	4.1	1.2	0.9	0.9	1.0

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). World includes international bunkers.

Table A25 Primary energy consumption, oil [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	3,232 (100)	3,660 (100)	4,210 (100)	4,616 (100)	5,121 (100)	5,496 (100)	1.2	1.3	1.0	0.7	1.0
Asia	618 (19.1)	917 (25.1)	1,254 (29.8)	1,483 (32.1)	1,771 (34.6)	2,053 (37.3)	3.1	2.4	1.8	1.5	1.8
China	119 (3.7)	221 (6.0)	478 (11.4)	595 (12.9)	704 (13.7)	797 (14.5)	6.2	3.2	1.7	1.2	1.9
India	61 (1.9)	112 (3.1)	176 (4.2)	248 (5.4)	348 (6.8)	451 (8.2)	4.7	5.0	3.5	2.6	3.5
Japan	250 (7.7)	255 (7.0)	202 (4.8)	175 (3.8)	155 (3.0)	135 (2.5)	-0.9	-2.1	-1.2	-1.3	-1.5
Korea	50 (1.5)	99 (2.7)	97 (2.3)	100 (2.2)	101 (2.0)	98 (1.8)	2.9	0.5	0.0	-0.3	0.0
Chinese Taipei	26 (0.8)	38 (1.0)	42 (1.0)	46 (1.0)	47 (0.9)	47 (0.8)	2.1	1.4	0.3	-0.2	0.4
ASEAN	88 (2.7)	153 (4.2)	209 (5.0)	256 (5.5)	333 (6.5)	422 (7.7)	3.8	2.9	2.7	2.4	2.6
Indonesia	33 (1.0)	58 (1.6)	77 (1.8)	93 (2.0)	119 (2.3)	155 (2.8)	3.7	2.8	2.5	2.6	2.6
Malaysia	11 (0.4)	19 (0.5)	31 (0.7)	38 (0.8)	46 (0.9)	52 (1.0)	4.5	3.0	1.9	1.3	2.0
Myanmar	1 (0.0)	2 (0.1)	3 (0.1)	4 (0.1)	6 (0.1)	9 (0.2)	6.0	4.3	4.2	4.5	4.3
Philippines	11 (0.3)	16 (0.4)	14 (0.3)	19 (0.4)	26 (0.5)	34 (0.6)	1.0	4.7	3.2	2.9	3.5
Singapore	11 (0.4)	17 (0.5)	16 (0.4)	18 (0.4)	21 (0.4)	23 (0.4)	1.5	1.8	1.6	0.6	1.3
Thailand	18 (0.6)	32 (0.9)	53 (1.3)	62 (1.4)	78 (1.5)	92 (1.7)	4.8	2.4	2.2	1.7	2.1
Viet Nam	3 (0.1)	8 (0.2)	16 (0.4)	21 (0.5)	37 (0.7)	56 (1.0)	7.9	4.4	5.7	4.4	4.9
Asia excl. Japan	367 (11.4)	662 (18.1)	1,051 (25.0)	1,309 (28.4)	1,616 (31.6)	1,917 (34.9)	4.7	3.2	2.1	1.7	2.3
North America	833 (25.8)	958 (26.2)	859 (20.4)	865 (18.7)	854 (16.7)	792 (14.4)	0.1	0.1	-0.1	-0.8	-0.3
United States	757 (23.4)	871 (23.8)	780 (18.5)	782 (16.9)	765 (14.9)	702 (12.8)	0.1	0.0	-0.2	-0.9	-0.4
Latin America	237 (7.3)	303 (8.3)	390 (9.3)	416 (9.0)	476 (9.3)	506 (9.2)	2.2	0.9	1.4	0.6	1.0
OECD Europe	606 (18.7)	650 (17.8)	549 (13.0)	519 (11.3)	490 (9.6)	454 (8.3)	-0.4	-0.8	-0.6	-0.8	-0.7
European Union	606 (18.7)	623 (17.0)	513 (12.2)	489 (10.6)	463 (9.0)	430 (7.8)	-0.7	-0.7	-0.5	-0.8	-0.7
Non-OECD Europe	468 (14.5)	203 (5.5)	242 (5.8)	248 (5.4)	260 (5.1)	262 (4.8)	-2.8	0.3	0.5	0.1	0.3
Africa	86 (2.7)	98 (2.7)	168 (4.0)	207 (4.5)	248 (4.8)	284 (5.2)	2.9	3.0	1.8	1.4	2.0
Middle East	146 (4.5)	217 (5.9)	342 (8.1)	393 (8.5)	455 (8.9)	509 (9.3)	3.8	2.0	1.5	1.1	1.5
Oceania	35 (1.1)	40 (1.1)	52 (1.2)	57 (1.2)	61 (1.2)	63 (1.2)	1.8	1.3	0.7	0.3	0.7
OECD	1,861 (57.6)	2,103 (57.5)	1,874 (44.5)	1,848 (40.0)	1,803 (35.2)	1,692 (30.8)	0.0	-0.2	-0.2	-0.6	-0.4
Non-OECD	1,169 (36.2)	1,283 (35.1)	1,982 (47.1)	2,340 (50.7)	2,811 (54.9)	3,230 (58.8)	2.3	2.4	1.9	1.4	1.8

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). World includes international bunkers.

Table A26 Primary energy consumption, natural gas [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	**1,663** (100)	**2,067** (100)	**2,902** (100)	**3,359** (100)	**4,096** (100)	**4,741** (100)	2.4	2.1	2.0	1.5	1.8
Asia	**116** (7.0)	**232** (11.2)	**532** (18.3)	**732** (21.8)	**1,083** (26.4)	**1,417** (29.9)	6.9	4.7	4.0	2.7	3.7
China	**13** (0.8)	**21** (1.0)	**140** (4.8)	**256** (7.6)	**431** (10.5)	**580** (12.2)	11.0	9.0	5.4	3.0	5.4
India	**11** (0.6)	**23** (1.1)	**44** (1.5)	**69** (2.0)	**120** (2.9)	**196** (4.1)	6.4	6.4	5.7	5.1	5.6
Japan	**44** (2.7)	**66** (3.2)	**106** (3.7)	**97** (2.9)	**110** (2.7)	**112** (2.4)	3.9	-1.4	1.3	0.1	0.2
Korea	**3** (0.2)	**17** (0.8)	**48** (1.6)	**47** (1.4)	**57** (1.4)	**58** (1.2)	13.2	-0.1	1.8	0.2	0.7
Chinese Taipei	**1** (0.1)	**6** (0.3)	**13** (0.5)	**19** (0.6)	**27** (0.7)	**30** (0.6)	10.2	5.7	3.3	1.0	3.1
ASEAN	**30** (1.8)	**74** (3.6)	**133** (4.6)	**175** (5.2)	**236** (5.8)	**305** (6.4)	6.7	4.0	3.0	2.6	3.1
Indonesia	**16** (1.0)	**27** (1.3)	**33** (1.1)	**51** (1.5)	**73** (1.8)	**99** (2.1)	3.2	6.5	3.6	3.1	4.2
Malaysia	**7** (0.4)	**25** (1.2)	**38** (1.3)	**44** (1.3)	**51** (1.2)	**57** (1.2)	7.8	2.1	1.5	1.2	1.5
Myanmar	**1** (0.0)	**1** (0.1)	**2** (0.1)	**3** (0.1)	**6** (0.1)	**8** (0.2)	3.9	9.1	5.2	3.6	5.6
Philippines	**-** (-)	**0** (0.0)	**3** (0.1)	**5** (0.1)	**7** (0.2)	**11** (0.2)	-	6.7	4.9	3.8	4.9
Singapore	**-** (-)	**1** (0.1)	**9** (0.3)	**10** (0.3)	**11** (0.3)	**13** (0.3)	-	1.1	1.7	1.3	1.4
Thailand	**5** (0.3)	**17** (0.8)	**38** (1.3)	**44** (1.3)	**56** (1.4)	**66** (1.4)	9.2	2.3	2.4	1.6	2.1
Viet Nam	**0** (0.0)	**1** (0.1)	**8** (0.3)	**15** (0.5)	**29** (0.7)	**49** (1.0)	41.9	8.8	6.7	5.4	6.7
Asia excl. Japan	**72** (4.3)	**167** (8.1)	**426** (14.7)	**635** (18.9)	**972** (23.7)	**1,305** (27.5)	8.1	5.9	4.4	3.0	4.2
North America	**493** (29.6)	**622** (30.1)	**697** (24.0)	**759** (22.6)	**826** (20.2)	**850** (17.9)	1.5	1.2	0.8	0.3	0.7
United States	**438** (26.3)	**548** (26.5)	**610** (21.0)	**668** (19.9)	**722** (17.6)	**742** (15.6)	1.4	1.3	0.8	0.3	0.7
Latin America	**72** (4.3)	**112** (5.4)	**199** (6.9)	**235** (7.0)	**328** (8.0)	**411** (8.7)	4.5	2.4	3.4	2.3	2.7
OECD Europe	**260** (15.6)	**393** (19.0)	**415** (14.3)	**454** (13.5)	**485** (11.9)	**498** (10.5)	2.1	1.3	0.7	0.2	0.7
European Union	**297** (17.9)	**396** (19.1)	**387** (13.3)	**420** (12.5)	**449** (11.0)	**461** (9.7)	1.2	1.2	0.7	0.2	0.7
Non-OECD Europe	**603** (36.2)	**489** (23.6)	**569** (19.6)	**579** (17.2)	**615** (15.0)	**641** (13.5)	-0.2	0.2	0.6	0.4	0.4
Africa	**30** (1.8)	**47** (2.3)	**100** (3.4)	**133** (3.9)	**192** (4.7)	**260** (5.5)	5.4	4.1	3.8	3.1	3.6
Middle East	**72** (4.3)	**148** (7.2)	**356** (12.3)	**422** (12.6)	**510** (12.4)	**593** (12.5)	7.2	2.5	1.9	1.5	1.9
Oceania	**19** (1.1)	**24** (1.2)	**34** (1.2)	**36** (1.1)	**36** (0.9)	**37** (0.8)	2.6	0.8	0.2	0.1	0.3
OECD	**843** (50.7)	**1,156** (55.9)	**1,365** (47.0)	**1,477** (44.0)	**1,612** (39.4)	**1,662** (35.1)	2.1	1.1	0.9	0.3	0.7
Non-OECD	**820** (49.3)	**911** (44.1)	**1,536** (53.0)	**1,873** (55.8)	**2,462** (60.1)	**3,044** (64.2)	2.8	2.9	2.8	2.1	2.6

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). World includes international bunkers.

Table A27 Final energy consumption [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	6,281 (100)	7,085 (100)	9,173 (100)	10,309 (100)	11,735 (100)	12,991 (100)	1.7	1.7	1.3	1.0	1.3
Asia	1,572 (25.0)	2,039 (28.8)	3,476 (37.9)	4,088 (39.7)	4,829 (41.1)	5,581 (43.0)	3.5	2.3	1.7	1.5	1.8
China	664 (10.6)	815 (11.5)	1,814 (19.8)	2,106 (20.4)	2,381 (20.3)	2,604 (20.0)	4.5	2.2	1.2	0.9	1.3
India	243 (3.9)	315 (4.5)	528 (5.8)	673 (6.5)	889 (7.6)	1,169 (9.0)	3.4	3.5	2.8	2.8	3.0
Japan	298 (4.7)	341 (4.8)	311 (3.4)	313 (3.0)	305 (2.6)	289 (2.2)	0.2	0.1	-0.2	-0.5	-0.3
Korea	65 (1.0)	127 (1.8)	168 (1.8)	185 (1.8)	199 (1.7)	197 (1.5)	4.2	1.4	0.7	-0.1	0.6
Chinese Taipei	29 (0.5)	49 (0.7)	68 (0.7)	75 (0.7)	81 (0.7)	82 (0.6)	3.7	1.6	0.7	0.2	0.7
ASEAN	173 (2.8)	271 (3.8)	425 (4.6)	532 (5.2)	701 (6.0)	897 (6.9)	4.0	3.3	2.8	2.5	2.8
Indonesia	80 (1.3)	121 (1.7)	162 (1.8)	205 (2.0)	269 (2.3)	351 (2.7)	3.1	3.4	2.8	2.7	2.9
Malaysia	14 (0.2)	30 (0.4)	54 (0.6)	69 (0.7)	87 (0.7)	103 (0.8)	6.1	3.5	2.3	1.8	2.4
Myanmar	9 (0.1)	11 (0.2)	15 (0.2)	17 (0.2)	22 (0.2)	28 (0.2)	2.1	2.0	2.2	2.4	2.2
Philippines	20 (0.3)	24 (0.3)	26 (0.3)	33 (0.3)	44 (0.4)	57 (0.4)	1.2	3.4	2.9	2.8	3.0
Singapore	5 (0.1)	8 (0.1)	20 (0.2)	23 (0.2)	28 (0.2)	31 (0.2)	6.1	2.5	1.9	1.0	1.7
Thailand	29 (0.5)	51 (0.7)	96 (1.0)	115 (1.1)	144 (1.2)	173 (1.3)	5.4	2.6	2.3	1.8	2.2
Viet Nam	16 (0.3)	25 (0.4)	51 (0.6)	68 (0.7)	105 (0.9)	151 (1.2)	5.2	4.1	4.5	3.7	4.1
Asia excl. Japan	1,275 (20.3)	1,698 (24.0)	3,165 (34.5)	3,775 (36.6)	4,524 (38.6)	5,291 (40.7)	4.0	2.6	1.8	1.6	1.9
North America	1,452 (23.1)	1,736 (24.5)	1,694 (18.5)	1,752 (17.0)	1,785 (15.2)	1,740 (13.4)	0.7	0.5	0.2	-0.3	0.1
United States	1,294 (20.6)	1,546 (21.8)	1,495 (16.3)	1,538 (14.9)	1,557 (13.3)	1,506 (11.6)	0.6	0.4	0.1	-0.3	0.0
Latin America	344 (5.5)	449 (6.3)	610 (6.6)	685 (6.6)	841 (7.2)	963 (7.4)	2.5	1.7	2.1	1.4	1.7
OECD Europe	1,122 (17.9)	1,225 (17.3)	1,219 (13.3)	1,256 (12.2)	1,268 (10.8)	1,254 (9.7)	0.4	0.4	0.1	-0.1	0.1
European Union	1,130 (18.0)	1,176 (16.6)	1,139 (12.4)	1,176 (11.4)	1,190 (10.1)	1,179 (9.1)	0.0	0.5	0.1	-0.1	0.1
Non-OECD Europe	1,073 (17.1)	654 (9.2)	704 (7.7)	757 (7.3)	838 (7.1)	896 (6.9)	-1.8	1.0	1.0	0.7	0.9
Africa	292 (4.6)	370 (5.2)	555 (6.0)	673 (6.5)	846 (7.2)	1,028 (7.9)	2.8	2.8	2.3	2.0	2.3
Middle East	157 (2.5)	255 (3.6)	467 (5.1)	558 (5.4)	685 (5.8)	801 (6.2)	4.9	2.6	2.1	1.6	2.0
Oceania	66 (1.1)	83 (1.2)	94 (1.0)	105 (1.0)	114 (1.0)	120 (0.9)	1.5	1.6	0.8	0.5	0.9
OECD	3,099 (49.3)	3,631 (51.2)	3,631 (39.6)	3,783 (36.7)	3,867 (33.0)	3,819 (29.4)	0.7	0.6	0.2	-0.1	0.2
Non-OECD	2,980 (47.4)	3,180 (44.9)	5,188 (56.6)	6,091 (59.1)	7,339 (62.5)	8,564 (65.9)	2.4	2.3	1.9	1.6	1.9

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). World includes international bunkers.

Table A28 Final energy consumption, industry [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	1,807 (100)	1,895 (100)	2,623 (100)	2,930 (100)	3,311 (100)	3,678 (100)	1.6	1.6	1.2	1.1	1.3
Asia	518 (28.7)	672 (35.5)	1,367 (52.1)	1,567 (53.5)	1,761 (53.2)	1,965 (53.4)	4.3	2.0	1.2	1.1	1.4
China	244 (13.5)	329 (17.3)	878 (33.5)	960 (32.8)	987 (29.8)	997 (27.1)	5.7	1.3	0.3	0.1	0.5
India	67 (3.7)	83 (4.4)	179 (6.8)	230 (7.9)	312 (9.4)	424 (11.5)	4.4	3.7	3.1	3.1	3.2
Japan	101 (5.6)	96 (5.1)	82 (3.1)	89 (3.0)	89 (2.7)	87 (2.4)	-0.9	1.1	0.0	-0.1	0.2
Korea	19 (1.1)	38 (2.0)	48 (1.8)	55 (1.9)	59 (1.8)	58 (1.6)	4.0	2.0	0.8	-0.3	0.7
Chinese Taipei	12 (0.7)	19 (1.0)	23 (0.9)	26 (0.9)	27 (0.8)	28 (0.8)	2.8	1.5	0.7	0.2	0.7
ASEAN	43 (2.4)	76 (4.0)	116 (4.4)	153 (5.2)	212 (6.4)	279 (7.6)	4.5	4.0	3.3	2.8	3.3
Indonesia	18 (1.0)	31 (1.6)	37 (1.4)	51 (1.8)	74 (2.2)	102 (2.8)	3.1	4.9	3.7	3.2	3.8
Malaysia	6 (0.3)	12 (0.6)	15 (0.6)	20 (0.7)	25 (0.8)	30 (0.8)	4.5	4.1	2.3	1.8	2.6
Myanmar	0 (0.0)	1 (0.1)	2 (0.1)	3 (0.1)	4 (0.1)	6 (0.2)	7.1	4.7	4.5	4.4	4.5
Philippines	5 (0.3)	5 (0.3)	7 (0.3)	9 (0.3)	11 (0.3)	14 (0.4)	1.7	3.2	2.6	2.4	2.7
Singapore	1 (0.0)	2 (0.1)	6 (0.2)	7 (0.2)	8 (0.3)	9 (0.3)	10.4	2.3	2.1	1.2	1.8
Thailand	9 (0.5)	17 (0.9)	30 (1.1)	35 (1.2)	45 (1.4)	55 (1.5)	5.5	2.4	2.5	2.0	2.3
Viet Nam	5 (0.3)	8 (0.4)	19 (0.7)	28 (0.9)	44 (1.3)	63 (1.7)	6.5	5.2	4.8	3.6	4.4
Asia excl. Japan	417 (23.1)	576 (30.4)	1,285 (49.0)	1,478 (50.4)	1,672 (50.5)	1,878 (51.1)	5.0	2.0	1.2	1.2	1.4
North America	331 (18.3)	387 (20.4)	309 (11.8)	318 (10.9)	314 (9.5)	303 (8.2)	-0.3	0.4	-0.1	-0.4	-0.1
United States	284 (15.7)	332 (17.5)	261 (10.0)	267 (9.1)	257 (7.8)	243 (6.6)	-0.4	0.3	-0.4	-0.6	-0.3
Latin America	115 (6.3)	148 (7.8)	199 (7.6)	220 (7.5)	279 (8.4)	335 (9.1)	2.4	1.5	2.4	1.9	2.0
OECD Europe	323 (17.9)	323 (17.1)	281 (10.7)	294 (10.0)	296 (9.0)	292 (7.9)	-0.6	0.6	0.1	-0.1	0.1
European Union	343 (19.0)	308 (16.2)	258 (9.8)	270 (9.2)	274 (8.3)	273 (7.4)	-1.2	0.7	0.2	-0.1	0.2
Non-OECD Europe	396 (21.9)	206 (10.9)	203 (7.7)	211 (7.2)	254 (7.7)	287 (7.8)	-2.9	0.6	1.8	1.3	1.3
Africa	55 (3.0)	58 (3.0)	85 (3.2)	107 (3.7)	142 (4.3)	183 (5.0)	1.9	3.4	2.9	2.5	2.9
Middle East	47 (2.6)	73 (3.8)	150 (5.7)	180 (6.1)	231 (7.0)	277 (7.5)	5.2	2.6	2.5	1.8	2.3
Oceania	23 (1.3)	28 (1.5)	29 (1.1)	33 (1.1)	35 (1.0)	36 (1.0)	1.1	1.5	0.6	0.3	0.7
OECD	826 (45.7)	908 (47.9)	794 (30.3)	839 (28.6)	851 (25.7)	843 (22.9)	-0.2	0.8	0.1	-0.1	0.2
Non-OECD	981 (54.3)	987 (52.1)	1,830 (69.7)	2,091 (71.4)	2,460 (74.3)	2,835 (77.1)	2.7	1.9	1.6	1.4	1.6

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%).

Table A29 Final energy consumption, transport [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	1,576 (100)	1,965 (100)	2,552 (100)	2,884 (100)	3,291 (100)	3,589 (100)	2.1	1.8	1.3	0.9	1.3
Asia	190 (12.1)	325 (16.6)	581 (22.8)	727 (25.2)	927 (28.2)	1,123 (31.3)	5.0	3.3	2.5	1.9	2.5
China	33 (2.1)	88 (4.5)	245 (9.6)	321 (11.1)	410 (12.5)	489 (13.6)	9.1	3.9	2.5	1.8	2.6
India	21 (1.3)	32 (1.6)	75 (2.9)	110 (3.8)	163 (5.0)	212 (5.9)	5.7	5.7	4.0	2.6	3.9
Japan	72 (4.6)	88 (4.5)	73 (2.9)	70 (2.4)	62 (1.9)	55 (1.5)	0.1	-0.8	-1.1	-1.1	-1.0
Korea	15 (0.9)	26 (1.3)	31 (1.2)	32 (1.1)	33 (1.0)	30 (0.8)	3.4	0.4	0.1	-0.7	-0.1
Chinese Taipei	7 (0.4)	12 (0.6)	12 (0.5)	13 (0.5)	14 (0.4)	13 (0.4)	2.6	1.1	0.4	-0.2	0.3
ASEAN	32 (2.1)	62 (3.1)	112 (4.4)	140 (4.9)	189 (5.8)	250 (7.0)	5.5	3.3	3.0	2.8	3.0
Indonesia	11 (0.7)	22 (1.1)	46 (1.8)	61 (2.1)	85 (2.6)	117 (3.3)	6.6	4.0	3.4	3.3	3.5
Malaysia	5 (0.3)	10 (0.5)	19 (0.8)	23 (0.8)	27 (0.8)	30 (0.8)	6.3	2.5	1.6	1.0	1.6
Myanmar	0 (0.0)	1 (0.1)	1 (0.1)	2 (0.1)	4 (0.1)	6 (0.2)	5.0	5.7	5.7	5.5	5.6
Philippines	5 (0.3)	8 (0.4)	9 (0.3)	12 (0.4)	17 (0.5)	24 (0.7)	2.9	4.4	3.7	3.4	3.8
Singapore	1 (0.1)	2 (0.1)	3 (0.1)	3 (0.1)	3 (0.1)	4 (0.1)	3.0	2.5	0.9	0.1	1.0
Thailand	9 (0.6)	15 (0.7)	23 (0.9)	25 (0.9)	27 (0.8)	27 (0.8)	4.1	1.4	0.6	0.3	0.7
Viet Nam	1 (0.1)	3 (0.2)	10 (0.4)	14 (0.5)	26 (0.8)	42 (1.2)	9.2	4.5	6.4	4.7	5.3
Asia excl. Japan	118 (7.5)	237 (12.1)	507 (19.9)	658 (22.8)	865 (26.3)	1,068 (29.8)	6.5	3.8	2.8	2.1	2.8
North America	531 (33.7)	640 (32.6)	669 (26.2)	684 (23.7)	679 (20.6)	634 (17.7)	1.0	0.3	-0.1	-0.7	-0.2
United States	488 (30.9)	588 (29.9)	608 (23.8)	618 (21.4)	611 (18.6)	569 (15.9)	1.0	0.2	-0.1	-0.7	-0.2
Latin America	103 (6.5)	141 (7.2)	216 (8.5)	252 (8.7)	312 (9.5)	346 (9.6)	3.3	2.2	2.2	1.0	1.8
OECD Europe	266 (16.9)	316 (16.1)	320 (12.6)	314 (10.9)	299 (9.1)	276 (7.7)	0.8	-0.3	-0.5	-0.8	-0.6
European Union	259 (16.4)	304 (15.5)	303 (11.9)	300 (10.4)	286 (8.7)	263 (7.3)	0.7	-0.1	-0.5	-0.8	-0.5
Non-OECD Europe	172 (10.9)	110 (5.6)	144 (5.7)	155 (5.4)	170 (5.2)	178 (5.0)	-0.8	1.0	0.9	0.5	0.8
Africa	38 (2.4)	54 (2.8)	97 (3.8)	121 (4.2)	145 (4.4)	164 (4.6)	4.2	3.3	1.8	1.2	2.0
Middle East	50 (3.2)	74 (3.8)	135 (5.3)	155 (5.4)	189 (5.7)	216 (6.0)	4.4	2.1	1.9	1.4	1.8
Oceania	24 (1.5)	30 (1.5)	36 (1.4)	39 (1.3)	42 (1.3)	44 (1.2)	1.7	1.2	0.7	0.4	0.7
OECD	938 (59.6)	1,143 (58.1)	1,189 (46.6)	1,215 (42.1)	1,202 (36.5)	1,133 (31.6)	1.0	0.3	-0.1	-0.6	-0.2
Non-OECD	435 (27.6)	549 (27.9)	1,009 (39.5)	1,233 (42.8)	1,560 (47.4)	1,847 (51.5)	3.7	2.9	2.4	1.7	2.3

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). World includes international bunkers.

Table A30 Final energy consumption, buildings, etc. [Reference Scenario]

(Mtoe)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	2,421 (100)	2,605 (100)	3,199 (100)	3,568 (100)	4,070 (100)	4,553 (100)	1.2	1.6	1.3	1.1	1.3
Asia	748 (30.9)	852 (32.7)	1,188 (37.1)	1,386 (38.8)	1,652 (40.6)	1,929 (42.4)	2.0	2.2	1.8	1.6	1.8
China	344 (14.2)	337 (12.9)	548 (17.1)	649 (18.2)	776 (19.1)	882 (19.4)	2.0	2.4	1.8	1.3	1.8
India	142 (5.9)	173 (6.6)	238 (7.4)	284 (8.0)	344 (8.5)	438 (9.6)	2.3	2.6	1.9	2.4	2.3
Japan	91 (3.8)	116 (4.4)	118 (3.7)	118 (3.3)	119 (2.9)	114 (2.5)	1.1	0.1	0.1	-0.5	-0.1
Korea	24 (1.0)	37 (1.4)	45 (1.4)	48 (1.3)	53 (1.3)	53 (1.2)	2.7	0.8	1.0	0.0	0.6
Chinese Taipei	7 (0.3)	10 (0.4)	12 (0.4)	13 (0.4)	14 (0.3)	14 (0.3)	2.5	1.5	0.5	0.1	0.6
ASEAN	87 (3.6)	113 (4.3)	143 (4.5)	171 (4.8)	212 (5.2)	261 (5.7)	2.2	2.5	2.2	2.1	2.2
Indonesia	44 (1.8)	59 (2.3)	68 (2.1)	79 (2.2)	96 (2.3)	115 (2.5)	1.9	2.2	1.9	1.9	2.0
Malaysia	3 (0.1)	5 (0.2)	10 (0.3)	14 (0.4)	20 (0.5)	27 (0.6)	5.7	4.9	3.6	2.7	3.6
Myanmar	8 (0.3)	9 (0.3)	12 (0.4)	13 (0.4)	14 (0.3)	15 (0.3)	1.4	1.0	0.9	0.9	0.9
Philippines	10 (0.4)	10 (0.4)	10 (0.3)	12 (0.3)	15 (0.4)	19 (0.4)	-0.2	2.6	2.3	2.3	2.4
Singapore	1 (0.0)	2 (0.1)	2 (0.1)	3 (0.1)	4 (0.1)	4 (0.1)	3.3	2.8	2.2	1.5	2.1
Thailand	11 (0.4)	14 (0.5)	21 (0.7)	26 (0.7)	33 (0.8)	40 (0.9)	3.0	2.6	2.4	2.1	2.4
Viet Nam	10 (0.4)	14 (0.5)	19 (0.6)	23 (0.7)	31 (0.8)	41 (0.9)	2.9	2.7	2.7	3.0	2.8
Asia excl. Japan	657 (27.1)	736 (28.2)	1,070 (33.5)	1,268 (35.5)	1,533 (37.7)	1,815 (39.9)	2.1	2.4	1.9	1.7	2.0
North America	457 (18.9)	535 (20.5)	573 (17.9)	597 (16.7)	619 (15.2)	623 (13.7)	1.0	0.6	0.4	0.1	0.3
United States	403 (16.7)	473 (18.1)	507 (15.8)	528 (14.8)	548 (13.5)	550 (12.1)	1.0	0.6	0.4	0.0	0.3
Latin America	101 (4.2)	120 (4.6)	154 (4.8)	169 (4.7)	202 (5.0)	230 (5.1)	1.9	1.3	1.8	1.3	1.5
OECD Europe	433 (17.9)	473 (18.1)	511 (16.0)	529 (14.8)	548 (13.5)	559 (12.3)	0.7	0.5	0.4	0.2	0.3
European Union	429 (17.7)	453 (17.4)	478 (14.9)	494 (13.9)	513 (12.6)	523 (11.5)	0.5	0.5	0.4	0.2	0.3
Non-OECD Europe	439 (18.1)	288 (11.1)	272 (8.5)	296 (8.3)	314 (7.7)	326 (7.2)	-2.1	1.2	0.6	0.4	0.7
Africa	188 (7.8)	243 (9.3)	354 (11.1)	421 (11.8)	530 (13.0)	647 (14.2)	2.8	2.5	2.3	2.0	2.3
Middle East	40 (1.7)	76 (2.9)	122 (3.8)	144 (4.0)	175 (4.3)	207 (4.5)	4.9	2.4	1.9	1.7	2.0
Oceania	15 (0.6)	19 (0.7)	23 (0.7)	26 (0.7)	29 (0.7)	32 (0.7)	1.9	1.8	1.2	0.9	1.2
OECD	1,044 (43.1)	1,209 (46.4)	1,305 (40.8)	1,358 (38.0)	1,415 (34.8)	1,434 (31.5)	1.0	0.6	0.4	0.1	0.4
Non-OECD	1,377 (56.9)	1,396 (53.6)	1,894 (59.2)	2,211 (62.0)	2,655 (65.2)	3,119 (68.5)	1.4	2.2	1.8	1.6	1.9

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%).

Table A31 Final energy consumption, electricity [Reference Scenario]

(TWh)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	**9,695** (100)	**12,688** (100)	**19,494** (100)	**23,110** (100)	**28,440** (100)	**33,613** (100)	3.1	2.5	2.1	1.7	2.0
Asia	**1,812** (18.7)	**3,229** (25.4)	**7,981** (40.9)	**10,211** (44.2)	**13,438** (47.2)	**16,751** (49.8)	6.7	3.6	2.8	2.2	2.8
China	**454** (4.7)	**1,037** (8.2)	**4,492** (23.0)	**5,741** (24.8)	**7,180** (25.2)	**8,315** (24.7)	10.5	3.6	2.3	1.5	2.3
India	**215** (2.2)	**376** (3.0)	**890** (4.6)	**1,266** (5.5)	**2,090** (7.4)	**3,283** (9.8)	6.4	5.2	5.1	4.6	5.0
Japan	**750** (7.7)	**944** (7.4)	**950** (4.9)	**1,026** (4.4)	**1,104** (3.9)	**1,133** (3.4)	1.0	1.1	0.7	0.3	0.7
Korea	**94** (1.0)	**263** (2.1)	**487** (2.5)	**595** (2.6)	**717** (2.5)	**750** (2.2)	7.4	2.9	1.9	0.5	1.6
Chinese Taipei	**77** (0.8)	**160** (1.3)	**227** (1.2)	**255** (1.1)	**285** (1.0)	**301** (0.9)	4.8	1.7	1.1	0.5	1.1
ASEAN	**130** (1.3)	**320** (2.5)	**713** (3.7)	**1,015** (4.4)	**1,589** (5.6)	**2,332** (6.9)	7.7	5.2	4.6	3.9	4.5
Indonesia	**28** (0.3)	**79** (0.6)	**188** (1.0)	**303** (1.3)	**501** (1.8)	**768** (2.3)	8.6	7.0	5.2	4.4	5.3
Malaysia	**20** (0.2)	**61** (0.5)	**127** (0.7)	**170** (0.7)	**246** (0.9)	**336** (1.0)	8.4	4.2	3.8	3.1	3.7
Myanmar	**2** (0.0)	**3** (0.0)	**9** (0.0)	**16** (0.1)	**30** (0.1)	**51** (0.2)	7.3	9.2	6.6	5.3	6.7
Philippines	**21** (0.2)	**37** (0.3)	**62** (0.3)	**85** (0.4)	**125** (0.4)	**173** (0.5)	4.7	4.7	3.9	3.3	3.9
Singapore	**13** (0.1)	**27** (0.2)	**46** (0.2)	**51** (0.2)	**61** (0.2)	**69** (0.2)	5.6	1.5	1.8	1.3	1.5
Thailand	**38** (0.4)	**88** (0.7)	**164** (0.8)	**202** (0.9)	**289** (1.0)	**388** (1.2)	6.5	3.0	3.6	3.0	3.2
Viet Nam	**6** (0.1)	**22** (0.2)	**114** (0.6)	**184** (0.8)	**332** (1.2)	**541** (1.6)	13.5	7.0	6.1	5.0	5.9
Asia excl. Japan	**1,063** (11.0)	**2,285** (18.0)	**7,031** (36.1)	**9,185** (39.7)	**12,334** (43.4)	**15,619** (46.5)	8.6	3.9	3.0	2.4	3.0
North America	**3,052** (31.5)	**3,981** (31.4)	**4,267** (21.9)	**4,671** (20.2)	**5,066** (17.8)	**5,239** (15.6)	1.5	1.3	0.8	0.3	0.8
United States	**2,634** (27.2)	**3,499** (27.6)	**3,782** (19.4)	**4,115** (17.8)	**4,470** (15.7)	**4,609** (13.7)	1.6	1.2	0.8	0.3	0.7
Latin America	**517** (5.3)	**810** (6.4)	**1,267** (6.5)	**1,478** (6.4)	**1,997** (7.0)	**2,492** (7.4)	4.0	2.2	3.1	2.2	2.5
OECD Europe	**2,230** (23.0)	**2,710** (21.4)	**3,048** (15.6)	**3,323** (14.4)	**3,584** (12.6)	**3,774** (11.2)	1.4	1.2	0.8	0.5	0.8
European Union	**2,163** (22.3)	**2,531** (19.9)	**2,771** (14.2)	**3,011** (13.0)	**3,259** (11.5)	**3,443** (10.2)	1.1	1.2	0.8	0.5	0.8
Non-OECD Europe	**1,471** (15.2)	**1,011** (8.0)	**1,256** (6.4)	**1,332** (5.8)	**1,587** (5.6)	**1,831** (5.4)	-0.7	0.8	1.8	1.4	1.4
Africa	**257** (2.7)	**361** (2.8)	**595** (3.1)	**769** (3.3)	**1,056** (3.7)	**1,401** (4.2)	3.7	3.7	3.2	2.9	3.2
Middle East	**199** (2.0)	**379** (3.0)	**835** (4.3)	**1,052** (4.6)	**1,405** (4.9)	**1,784** (5.3)	6.4	3.3	2.9	2.4	2.8
Oceania	**157** (1.6)	**207** (1.6)	**244** (1.3)	**275** (1.2)	**309** (1.1)	**340** (1.0)	1.9	1.7	1.2	1.0	1.2
OECD	**6,399** (66.0)	**8,304** (65.4)	**9,304** (47.7)	**10,258** (44.4)	**11,256** (39.6)	**11,838** (35.2)	1.6	1.4	0.9	0.5	0.9
Non-OECD	**3,296** (34.0)	**4,384** (34.6)	**10,191** (52.3)	**12,852** (55.6)	**17,184** (60.4)	**21,775** (64.8)	5.0	3.4	2.9	2.4	2.9

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%).

Table A32 Electricity generation [Reference Scenario]

(TWh)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	11,826 (100)	15,426 (100)	23,307 (100)	27,414 (100)	33,547 (100)	39,509 (100)	3.0	2.3	2.0	1.6	2.0
Asia	2,215 (18.7)	3,974 (25.8)	9,481 (40.7)	12,018 (43.8)	15,719 (46.9)	19,519 (49.4)	6.5	3.4	2.7	2.2	2.7
China	621 (5.3)	1,356 (8.8)	5,422 (23.3)	6,833 (24.9)	8,459 (25.2)	9,728 (24.6)	9.9	3.4	2.2	1.4	2.2
India	293 (2.5)	570 (3.7)	1,193 (5.1)	1,675 (6.1)	2,714 (8.1)	4,196 (10.6)	6.3	5.0	4.9	4.5	4.8
Japan	836 (7.1)	1,049 (6.8)	1,038 (4.5)	1,116 (4.1)	1,188 (3.5)	1,200 (3.0)	0.9	1.0	0.6	0.1	0.5
Korea	105 (0.9)	289 (1.9)	538 (2.3)	647 (2.4)	777 (2.3)	812 (2.1)	7.3	2.7	1.9	0.4	1.5
Chinese Taipei	88 (0.7)	181 (1.2)	249 (1.1)	280 (1.0)	311 (0.9)	327 (0.8)	4.6	1.7	1.1	0.5	1.0
ASEAN	154 (1.3)	370 (2.4)	786 (3.4)	1,117 (4.1)	1,738 (5.2)	2,538 (6.4)	7.3	5.1	4.5	3.9	4.4
Indonesia	33 (0.3)	93 (0.6)	216 (0.9)	345 (1.3)	570 (1.7)	871 (2.2)	8.6	7.0	5.1	4.3	5.3
Malaysia	23 (0.2)	69 (0.4)	138 (0.6)	185 (0.7)	267 (0.8)	363 (0.9)	8.1	4.2	3.7	3.1	3.6
Myanmar	2 (0.0)	5 (0.0)	12 (0.1)	22 (0.1)	40 (0.1)	65 (0.2)	7.1	8.9	6.3	5.0	6.5
Philippines	26 (0.2)	45 (0.3)	75 (0.3)	104 (0.4)	150 (0.4)	206 (0.5)	4.7	4.7	3.8	3.2	3.8
Singapore	16 (0.1)	32 (0.2)	48 (0.2)	53 (0.2)	63 (0.2)	72 (0.2)	5.0	1.5	1.8	1.3	1.5
Thailand	44 (0.4)	96 (0.6)	166 (0.7)	201 (0.7)	280 (0.8)	367 (0.9)	5.9	2.8	3.4	2.7	3.0
Viet Nam	9 (0.1)	27 (0.2)	127 (0.5)	201 (0.7)	361 (1.1)	587 (1.5)	12.4	6.8	6.0	5.0	5.8
Asia excl. Japan	1,380 (11.7)	2,925 (19.0)	8,442 (36.2)	10,903 (39.8)	14,531 (43.3)	18,319 (46.4)	8.2	3.7	2.9	2.3	2.9
North America	3,685 (31.2)	4,631 (30.0)	4,939 (21.2)	5,381 (19.6)	5,811 (17.3)	5,999 (15.2)	1.3	1.2	0.8	0.3	0.7
United States	3,203 (27.1)	4,026 (26.1)	4,287 (18.4)	4,652 (17.0)	5,037 (15.0)	5,188 (13.1)	1.3	1.2	0.8	0.3	0.7
Latin America	623 (5.3)	1,003 (6.5)	1,553 (6.7)	1,787 (6.5)	2,377 (7.1)	2,937 (7.4)	4.0	2.0	2.9	2.1	2.4
OECD Europe	2,662 (22.5)	3,223 (20.9)	3,559 (15.3)	3,876 (14.1)	4,171 (12.4)	4,388 (11.1)	1.3	1.2	0.7	0.5	0.8
European Union	2,576 (21.8)	3,005 (19.5)	3,230 (13.9)	3,511 (12.8)	3,806 (11.3)	4,041 (10.2)	1.0	1.2	0.8	0.6	0.8
Non-OECD Europe	1,894 (16.0)	1,432 (9.3)	1,740 (7.5)	1,827 (6.7)	2,156 (6.4)	2,465 (6.2)	-0.4	0.7	1.7	1.3	1.3
Africa	316 (2.7)	442 (2.9)	732 (3.1)	933 (3.4)	1,271 (3.8)	1,678 (4.2)	3.7	3.5	3.1	2.8	3.1
Middle East	244 (2.1)	472 (3.1)	1,012 (4.3)	1,262 (4.6)	1,671 (5.0)	2,115 (5.4)	6.4	3.2	2.8	2.4	2.8
Oceania	187 (1.6)	249 (1.6)	292 (1.3)	329 (1.2)	370 (1.1)	408 (1.0)	2.0	1.7	1.2	1.0	1.2
OECD	7,608 (64.3)	9,685 (62.8)	10,736 (46.1)	11,789 (43.0)	12,883 (38.4)	13,513 (34.2)	1.5	1.3	0.9	0.5	0.9
Non-OECD	4,218 (35.7)	5,741 (37.2)	12,571 (53.9)	15,625 (57.0)	20,663 (61.6)	25,996 (65.8)	4.9	3.2	2.8	2.3	2.7

Source: International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%).

Table A33 GDP per capita [Reference Scenario]

($2010 thousand/person)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
World	7.1	8.1	9.9	11.3	14.0	16.8	1.5	1.9	2.1	1.8	2.0
Asia	2.5	3.1	5.1	6.7	9.8	13.4	3.1	4.1	3.8	3.2	3.6
China	0.7	1.7	5.5	8.3	14.0	21.0	9.3	6.0	5.3	4.1	5.1
India	0.6	0.8	1.6	2.5	4.3	7.1	4.8	6.3	5.6	5.0	5.6
Japan	36.9	40.2	44.4	52.2	62.8	73.3	0.8	2.3	1.9	1.6	1.9
Korea	8.8	15.1	23.8	29.5	37.5	45.0	4.4	3.1	2.4	1.8	2.4
Chinese Taipei	8.2	13.7	20.6	27.1	34.1	40.2	4.1	4.0	2.3	1.7	2.5
ASEAN	1.6	2.3	3.7	4.8	7.0	9.6	3.6	4.0	3.7	3.2	3.6
Indonesia	1.6	2.0	3.4	4.6	6.9	9.8	3.4	4.5	4.0	3.6	4.0
Malaysia	4.4	6.7	9.7	12.5	17.4	22.3	3.5	3.7	3.4	2.5	3.1
Myanmar	0.2	0.3	1.0	1.5	2.6	3.9	8.1	7.1	5.3	4.3	5.4
Philippines	1.5	1.6	2.4	3.3	4.5	6.1	2.0	4.6	3.2	3.0	3.5
Singapore	22.2	33.4	49.4	55.1	68.0	75.2	3.5	1.6	2.1	1.0	1.6
Thailand	2.4	3.3	5.2	6.5	9.4	13.2	3.5	3.2	3.7	3.4	3.5
Viet Nam	0.4	0.8	1.5	2.1	3.8	5.8	5.5	4.9	5.8	4.5	5.1
Asia excl. Japan	1.0	1.7	3.8	5.3	8.3	11.9	5.9	5.0	4.5	3.7	4.3
North America	36.3	44.9	50.2	56.5	66.9	76.2	1.4	1.7	1.7	1.3	1.6
United States	36.3	45.1	50.3	56.9	67.6	77.1	1.4	1.8	1.7	1.3	1.6
Latin America	6.3	7.2	9.3	9.9	12.7	15.4	1.7	0.9	2.5	2.0	1.9
OECD Europe	25.3	30.4	33.5	37.2	42.7	47.8	1.2	1.5	1.4	1.1	1.3
European Union	24.8	30.2	33.8	37.6	43.5	49.0	1.4	1.5	1.5	1.2	1.4
Non-OECD Europe	6.3	4.4	7.9	8.5	11.6	15.0	1.0	1.0	3.1	2.6	2.4
Africa	1.4	1.4	1.9	2.2	2.8	3.4	1.3	2.2	2.2	2.1	2.2
Middle East	6.9	8.4	10.7	11.7	13.7	15.5	2.0	1.2	1.6	1.3	1.4
Oceania	35.3	43.1	52.5	58.7	66.1	71.8	1.7	1.6	1.2	0.8	1.2
OECD	27.3	32.8	36.7	41.3	48.5	55.2	1.3	1.7	1.6	1.3	1.5
Non-OECD	2.0	2.4	4.2	5.2	7.4	9.9	3.2	3.3	3.6	2.9	3.2

Source: World Bank "World Development Indicators", International Energy Agency "World Energy Balances", etc. (historical)

Table A34 Primary energy consumption per capita [Reference Scenario]

(toe/person)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	1.66	1.65	1.91	1.98	2.04	2.09	0.6	0.5	0.3	0.2	0.3
Asia	0.72	0.86	1.39	1.55	1.72	1.90	2.9	1.6	1.0	1.0	1.2
China	0.77	0.92	2.23	2.50	2.78	3.04	4.7	1.7	1.0	0.9	1.2
India	0.35	0.42	0.62	0.73	0.91	1.14	2.5	2.4	2.2	2.3	2.3
Japan	3.56	4.09	3.57	3.76	3.83	3.82	0.0	0.7	0.2	0.0	0.3
Korea	2.17	4.00	5.25	5.81	6.20	6.16	3.9	1.5	0.7	-0.1	0.6
Chinese Taipei	2.34	3.81	4.65	5.10	5.45	5.72	3.0	1.3	0.7	0.5	0.8
ASEAN	0.55	0.76	0.99	1.21	1.49	1.81	2.6	3.0	2.1	2.0	2.3
Indonesia	0.55	0.74	0.86	1.16	1.43	1.74	1.9	4.5	2.1	2.0	2.7
Malaysia	1.22	2.11	2.99	3.34	3.70	4.07	4.0	1.6	1.0	1.0	1.1
Myanmar	0.25	0.27	0.31	0.35	0.42	0.52	0.9	1.9	1.8	2.1	1.9
Philippines	0.46	0.51	0.45	0.53	0.61	0.71	-0.1	2.1	1.5	1.6	1.7
Singapore	3.78	4.63	4.83	5.18	5.81	6.18	1.1	1.0	1.2	0.6	0.9
Thailand	0.74	1.16	2.00	2.33	2.98	3.72	4.4	2.2	2.5	2.2	2.3
Viet Nam	0.27	0.37	0.67	0.86	1.32	1.91	4.0	3.6	4.4	3.8	4.0
Asia excl. Japan	0.59	0.73	1.32	1.48	1.66	1.85	3.5	1.7	1.1	1.1	1.3
North America	7.66	8.07	6.95	6.81	6.43	5.94	-0.4	-0.3	-0.6	-0.8	-0.6
United States	7.67	8.06	6.92	6.78	6.37	5.85	-0.4	-0.3	-0.6	-0.8	-0.6
Latin America	1.05	1.14	1.39	1.47	1.68	1.84	1.2	0.8	1.4	0.9	1.1
OECD Europe	3.25	3.35	3.12	3.14	3.12	3.07	-0.2	0.1	-0.1	-0.2	-0.1
European Union	3.44	3.47	3.21	3.24	3.24	3.20	-0.3	0.2	0.0	-0.1	0.0
Non-OECD Europe	4.47	2.94	3.38	3.41	3.65	3.87	-1.2	0.1	0.7	0.6	0.5
Africa	0.62	0.61	0.67	0.69	0.69	0.67	0.3	0.3	0.0	-0.2	0.0
Middle East	1.69	2.25	3.16	3.27	3.40	3.50	2.8	0.5	0.4	0.3	0.4
Oceania	4.86	5.44	5.39	5.36	5.06	4.76	0.4	-0.1	-0.6	-0.6	-0.5
OECD	4.25	4.59	4.21	4.25	4.17	4.03	0.0	0.1	-0.2	-0.4	-0.2
Non-OECD	0.96	0.91	1.35	1.45	1.56	1.66	1.5	1.0	0.8	0.6	0.8

Source: World Bank "World Development Indicators", International Energy Agency "World Energy Balances", etc. (historical)

Note: World includes international bunkers.

Table A35 Primary energy consumption per GDP [Reference Scenario]

(toe/$2010 million)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	234	204	192	175	146	125	-0.8	-1.4	-1.8	-1.6	-1.6
Asia	285	273	272	230	176	142	-0.2	-2.4	-2.6	-2.1	-2.4
China	1,073	530	402	300	198	145	-4.2	-4.1	-4.1	-3.1	-3.7
India	640	535	380	293	210	162	-2.2	-3.7	-3.3	-2.6	-3.1
Japan	96	102	80	72	61	52	-0.8	-1.6	-1.7	-1.6	-1.6
Korea	246	265	221	197	165	137	-0.5	-1.6	-1.7	-1.9	-1.8
Chinese Taipei	286	278	226	188	160	142	-1.0	-2.6	-1.6	-1.2	-1.7
ASEAN	332	334	268	251	214	189	-0.9	-0.9	-1.6	-1.2	-1.3
Indonesia	350	365	252	252	208	178	-1.4	0.0	-1.9	-1.6	-1.3
Malaysia	279	314	309	267	213	183	0.4	-2.0	-2.3	-1.5	-1.9
Myanmar	1,599	964	327	230	164	132	-6.7	-4.9	-3.3	-2.2	-3.3
Philippines	304	319	188	160	135	118	-2.1	-2.3	-1.7	-1.4	-1.7
Singapore	171	139	98	94	85	82	-2.4	-0.6	-0.9	-0.4	-0.6
Thailand	311	346	383	358	317	282	0.9	-1.0	-1.2	-1.2	-1.1
Viet Nam	606	470	439	403	352	327	-1.4	-1.2	-1.3	-0.7	-1.1
Asia excl. Japan	587	429	349	278	200	156	-2.2	-3.2	-3.2	-2.5	-2.9
North America	211	180	139	120	96	78	-1.8	-2.0	-2.2	-2.1	-2.1
United States	211	179	138	119	94	76	-1.9	-2.0	-2.3	-2.1	-2.2
Latin America	168	159	149	148	133	119	-0.5	-0.1	-1.1	-1.1	-0.8
OECD Europe	128	110	93	84	73	64	-1.4	-1.4	-1.5	-1.3	-1.4
European Union	139	115	95	86	74	65	-1.6	-1.3	-1.5	-1.3	-1.4
Non-OECD Europe	709	665	427	400	315	258	-2.2	-0.9	-2.4	-2.0	-1.8
Africa	441	432	353	310	248	198	-1.0	-1.8	-2.2	-2.3	-2.1
Middle East	246	269	295	280	248	225	0.8	-0.7	-1.2	-1.0	-1.0
Oceania	138	126	103	91	77	66	-1.3	-1.7	-1.7	-1.4	-1.6
OECD	155	140	115	103	86	73	-1.3	-1.5	-1.8	-1.6	-1.7
Non-OECD	478	387	323	276	210	168	-1.7	-2.2	-2.7	-2.2	-2.4

Source: World Bank "World Development Indicators", International Energy Agency "World Energy Balances", etc. (historical)

Note: World includes international bunkers.

Table A36 Energy–related carbon dioxide emissions [Reference Scenario]

(Mt)

	1990	2000	2013	2020	2030	2040	CAGR (%) 1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
World	**21,200** (100)	**23,520** (100)	**32,920** (100)	**35,719** (100)	**39,498** (100)	**42,693** (100)	1.9	1.2	1.0	0.8	1.0
Asia	**4,920** (23.2)	**6,989** (29.7)	**14,936** (45.4)	**16,874** (47.2)	**19,447** (49.2)	**21,966** (51.4)	4.9	1.8	1.4	1.2	1.4
China	**2,339** (11.0)	**3,258** (13.9)	**9,437** (28.7)	**10,406** (29.1)	**11,196** (28.3)	**11,627** (27.2)	6.3	1.4	0.7	0.4	0.8
India	**546** (2.6)	**901** (3.8)	**1,894** (5.8)	**2,480** (6.9)	**3,459** (8.8)	**4,757** (11.1)	5.6	3.9	3.4	3.2	3.5
Japan	**1,070** (5.0)	**1,196** (5.1)	**1,234** (3.7)	**1,120** (3.1)	**1,105** (2.8)	**1,034** (2.4)	0.6	-1.4	-0.1	-0.7	-0.7
Korea	**239** (1.1)	**433** (1.8)	**582** (1.8)	**583** (1.6)	**631** (1.6)	**606** (1.4)	3.9	0.0	0.8	-0.4	0.1
Chinese Taipei	**115** (0.5)	**225** (1.0)	**255** (0.8)	**272** (0.8)	**285** (0.7)	**282** (0.7)	3.5	0.9	0.5	-0.1	0.4
ASEAN	**362** (1.7)	**710** (3.0)	**1,162** (3.5)	**1,519** (4.3)	**2,102** (5.3)	**2,814** (6.6)	5.2	3.9	3.3	3.0	3.3
Indonesia	**134** (0.6)	**262** (1.1)	**406** (1.2)	**582** (1.6)	**836** (2.1)	**1,158** (2.7)	4.9	5.3	3.7	3.3	4.0
Malaysia	**54** (0.3)	**120** (0.5)	**222** (0.7)	**269** (0.8)	**327** (0.8)	**377** (0.9)	6.3	2.8	2.0	1.4	2.0
Myanmar	**4** (0.0)	**10** (0.0)	**14** (0.0)	**22** (0.1)	**35** (0.1)	**54** (0.1)	5.4	6.8	5.0	4.3	5.2
Philippines	**39** (0.2)	**69** (0.3)	**90** (0.3)	**117** (0.3)	**171** (0.4)	**235** (0.6)	3.8	3.8	3.8	3.3	3.6
Singapore	**29** (0.1)	**48** (0.2)	**45** (0.1)	**48** (0.1)	**55** (0.1)	**59** (0.1)	1.9	1.0	1.4	0.7	1.0
Thailand	**81** (0.4)	**152** (0.6)	**254** (0.8)	**288** (0.8)	**352** (0.9)	**411** (1.0)	5.1	1.8	2.0	1.6	1.8
Viet Nam	**17** (0.1)	**43** (0.2)	**125** (0.4)	**185** (0.5)	**319** (0.8)	**512** (1.2)	9.0	5.9	5.6	4.8	5.4
Asia excl. Japan	**3,850** (18.2)	**5,793** (24.6)	**13,702** (41.6)	**15,754** (44.1)	**18,342** (46.4)	**20,932** (49.0)	5.7	2.0	1.5	1.3	1.6
North America	**5,236** (24.7)	**6,125** (26.0)	**5,626** (17.1)	**5,632** (15.8)	**5,414** (13.7)	**4,962** (11.6)	0.3	0.0	-0.4	-0.9	-0.5
United States	**4,820** (22.7)	**5,617** (23.9)	**5,184** (15.7)	**5,186** (14.5)	**4,954** (12.5)	**4,517** (10.6)	0.3	0.0	-0.5	-0.9	-0.5
Latin America	**905** (4.3)	**1,187** (5.0)	**1,718** (5.2)	**1,881** (5.3)	**2,333** (5.9)	**2,664** (6.2)	2.8	1.3	2.2	1.3	1.6
OECD Europe	**3,952** (18.6)	**3,891** (16.5)	**3,560** (10.8)	**3,468** (9.7)	**3,398** (8.6)	**3,227** (7.6)	-0.5	-0.4	-0.2	-0.5	-0.4
European Union	**4,068** (19.2)	**3,783** (16.1)	**3,320** (10.1)	**3,239** (9.1)	**3,184** (8.1)	**3,023** (7.1)	-0.9	-0.4	-0.2	-0.5	-0.3
Non-OECD Europe	**4,123** (19.4)	**2,462** (10.5)	**2,720** (8.3)	**2,698** (7.6)	**2,757** (7.0)	**2,794** (6.5)	-1.8	-0.1	0.2	0.1	0.1
Africa	**593** (2.8)	**718** (3.1)	**1,108** (3.4)	**1,377** (3.9)	**1,702** (4.3)	**2,050** (4.8)	2.8	3.2	2.1	1.9	2.3
Middle East	**571** (2.7)	**952** (4.0)	**1,756** (5.3)	**2,028** (5.7)	**2,402** (6.1)	**2,754** (6.4)	5.0	2.1	1.7	1.4	1.7
Oceania	**281** (1.3)	**357** (1.5)	**410** (1.2)	**428** (1.2)	**437** (1.1)	**433** (1.0)	1.7	0.6	0.2	-0.1	0.2
OECD	**11,096** (52.3)	**12,396** (52.7)	**11,975** (36.4)	**11,898** (33.3)	**11,753** (29.8)	**11,118** (26.0)	0.3	-0.1	-0.1	-0.6	-0.3
Non-OECD	**9,484** (44.7)	**10,284** (43.7)	**19,859** (60.3)	**22,489** (63.0)	**26,137** (66.2)	**29,732** (69.6)	3.3	1.8	1.5	1.3	1.5

Source: Compiled from International Energy Agency "World Energy Balances" (historical)

Note: Figures in parentheses are global shares (%). Excludes emission reduction by CCS. World includes international bunkers.

Table A37 World [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
Total[*1]	7,205	8,768	10,057	13,555	15,207	17,211	18,963	100	100	100	1.9	1.7	1.2	1.0	1.3
Coal	1,783	2,221	2,343	3,928	4,143	4,367	4,577	25	29	24	2.5	0.8	0.5	0.5	0.6
Oil	3,102	3,232	3,660	4,210	4,616	5,121	5,496	37	31	29	1.2	1.3	1.0	0.7	1.0
Natural gas	1,232	1,663	2,067	2,902	3,359	4,096	4,741	19	21	25	2.4	2.1	2.0	1.5	1.8
Nuclear	186	526	676	646	844	981	1,127	6.0	4.8	5.9	0.9	3.9	1.5	1.4	2.1
Hydro	148	184	225	326	369	402	434	2.1	2.4	2.3	2.5	1.8	0.9	0.8	1.1
Geothermal	12	34	52	66	146	190	229	0.4	0.5	1.2	2.9	12.0	2.7	1.9	4.7
Solar, wind, etc.	0.1	2.4	7.9	95	145	220	301	0.0	0.7	1.6	17.3	6.2	4.3	3.2	4.4
Biomass and waste	741	905	1,025	1,377	1,580	1,825	2,048	10	10	11	1.8	2.0	1.5	1.2	1.5

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
Total	5,375	6,281	7,085	9,173	10,309	11,735	12,991	100	100	100	1.7	1.7	1.3	1.0	1.3
Industry	1,773	1,807	1,895	2,623	2,930	3,311	3,678	29	29	28	1.6	1.6	1.2	1.1	1.3
Transport	1,248	1,576	1,965	2,552	2,884	3,291	3,589	25	28	28	2.1	1.8	1.3	0.9	1.3
Buildings, etc.	2,000	2,421	2,605	3,199	3,568	4,070	4,553	39	35	35	1.2	1.6	1.3	1.1	1.3
Non-energy use	354	477	619	799	927	1,064	1,172	7.6	8.7	9.0	2.3	2.1	1.4	1.0	1.4
Coal	709	766	578	954	1,007	1,000	994	12	10	7.7	1.0	0.8	-0.1	-0.1	0.2
Oil	2,446	2,606	3,127	3,704	4,113	4,616	4,992	41	40	38	1.5	1.5	1.2	0.8	1.1
Natural gas	814	944	1,121	1,400	1,613	1,903	2,174	15	15	17	1.7	2.0	1.7	1.3	1.6
Electricity	586	834	1,091	1,677	1,987	2,446	2,891	13	18	22	3.1	2.5	2.1	1.7	2.0
Heat	121	335	247	274	299	325	339	5.3	3.0	2.6	-0.9	1.3	0.8	0.4	0.8
Hydrogen	-	-	-	-	0.0	0.7	1.3	-	-	0.0	n.a.	n.a.	36.4	6.6	n.a.
Renewables	698	796	920	1,164	1,289	1,445	1,601	13	13	12	1.7	1.5	1.1	1.0	1.2

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
Total	8,283	11,826	15,426	23,307	27,414	33,547	39,509	100	100	100	3.0	2.3	2.0	1.6	2.0
Coal	3,137	4,424	6,002	9,613	10,427	12,079	13,687	37	41	35	3.4	1.2	1.5	1.3	1.3
Oil	1,659	1,311	1,205	1,028	948	991	1,032	11	4.4	2.6	-1.1	-1.1	0.4	0.4	0.0
Natural gas	999	1,760	2,752	5,075	6,338	8,815	11,205	15	22	28	4.7	3.2	3.4	2.4	3.0
Nuclear	713	2,013	2,591	2,478	3,235	3,760	4,321	17	11	11	0.9	3.9	1.5	1.4	2.1
Hydro	1,717	2,145	2,620	3,790	4,293	4,679	5,046	18	16	13	2.5	1.8	0.9	0.8	1.1
Geothermal	14	36	52	72	150	194	239	0.3	0.3	0.6	3.0	11.1	2.6	2.1	4.6
Solar, wind, etc.	0.5	5.2	35	789	1,326	2,058	2,778	0.0	3.4	7.0	24.4	7.7	4.5	3.0	4.8
Biomass and waste	44	132	170	461	694	968	1,199	1.1	2.0	3.0	5.6	6.0	3.4	2.2	3.6

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
GDP ($2010 billion)	27,780	37,514	49,355	70,542	87,139	118,035	152,280	2.8	3.1	3.1	2.6	2.9
Population (million)	4,435	5,271	6,093	7,114	7,685	8,420	9,068	1.3	1.1	0.9	0.7	0.9
CO_2 emissions[*2] (Mt)	18,411	21,200	23,520	32,920	35,719	39,498	42,693	1.9	1.2	1.0	0.8	1.0
GDP per capita ($2010 thousand)	6.3	7.1	8.1	9.9	11	14	17	1.5	1.9	2.1	1.8	2.0
Primary energy consump. per capita (toe)	1.6	1.7	1.7	1.9	2.0	2.0	2.1	0.6	0.5	0.3	0.2	0.3
Primary energy consumption per GDP[*3]	259	234	204	192	175	146	125	-0.8	-1.4	-1.8	-1.6	-1.6
CO_2 emissions per GDP[*2, *4]	663	565	477	467	410	335	280	-0.8	-1.8	-2.0	-1.8	-1.9
CO_2 per primary energy consumption[*2, *5]	2.6	2.4	2.3	2.4	2.3	2.3	2.3	0.0	-0.5	-0.2	-0.2	-0.3
Automobile ownership (million)	416	577	767	1,195	1,449	1,802	2,142	3.2	2.8	2.2	1.7	2.2
Automobile ownership rates[*6]	94	109	126	168	189	214	236	1.9	1.7	1.3	1.0	1.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A38 Asia [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,440	2,110	2,920	5,409	6,411	7,567	8,691	100	100	100	4.2	2.5	1.7	1.4	1.8
Coal	466	786	1,063	2,747	2,992	3,271	3,546	37	51	41	5.6	1.2	0.9	0.8	0.9
Oil	477	618	917	1,254	1,483	1,771	2,053	29	23	24	3.1	2.4	1.8	1.5	1.8
Natural gas	51	116	232	532	732	1,083	1,417	5.5	9.8	16	6.9	4.7	4.0	2.7	3.7
Nuclear	25	77	132	89	270	373	478	3.6	1.6	5.5	0.6	17.2	3.3	2.5	6.4
Hydro	20	32	41	113	145	163	182	1.5	2.1	2.1	5.7	3.6	1.2	1.1	1.8
Geothermal	2.6	8.2	23	31	78	102	116	0.4	0.6	1.3	6.0	13.8	2.8	1.3	5.0
Solar, wind, etc.	-	1.2	2.1	38	60	95	138	0.1	0.7	1.6	16.1	6.5	4.7	3.8	4.8
Biomass and waste	397	472	510	602	649	706	757	22	11	8.7	1.1	1.1	0.8	0.7	0.9

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,136	1,572	2,039	3,476	4,088	4,829	5,581	100	100	100	3.5	2.3	1.7	1.5	1.8
Industry	390	518	672	1,367	1,567	1,761	1,965	33	39	35	4.3	2.0	1.2	1.1	1.4
Transport	126	190	325	581	727	927	1,123	12	17	20	5.0	3.3	2.5	1.9	2.5
Buildings, etc.	567	748	852	1,188	1,386	1,652	1,929	48	34	35	2.0	2.2	1.8	1.6	1.8
Non-energy use	54	116	190	340	408	489	564	7.4	9.8	10	4.8	2.6	1.8	1.4	1.9
Coal	308	435	408	795	839	827	817	28	23	15	2.7	0.8	-0.1	-0.1	0.1
Oil	327	464	742	1,102	1,344	1,623	1,897	30	32	34	3.8	2.9	1.9	1.6	2.0
Natural gas	21	47	89	248	342	496	658	3.0	7.1	12	7.5	4.7	3.8	2.9	3.7
Electricity	88	156	278	686	878	1,156	1,441	9.9	20	26	6.7	3.6	2.8	2.2	2.8
Heat	7.5	14	30	82	95	104	108	0.9	2.4	1.9	7.9	2.2	0.9	0.3	1.0
Hydrogen	-	-	-	-	0.0	0.2	0.4	-	-	0.0	n.a.	n.a.	22.1	7.4	n.a.
Renewables	386	456	493	562	589	623	660	29	16	12	0.9	0.7	0.6	0.6	0.6

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,196	2,215	3,974	9,481	12,018	15,719	19,519	100	100	100	6.5	3.4	2.7	2.2	2.7
Coal	298	862	1,990	5,939	6,784	8,513	10,257	39	63	53	8.8	1.9	2.3	1.9	2.0
Oil	476	422	386	306	218	209	206	19	3.2	1.1	-1.4	-4.7	-0.4	-0.2	-1.5
Natural gas	90	247	567	1,206	1,622	2,615	3,652	11	13	19	7.1	4.3	4.9	3.4	4.2
Nuclear	97	294	505	340	1,035	1,430	1,833	13	3.6	9.4	0.6	17.2	3.3	2.5	6.4
Hydro	232	370	481	1,319	1,686	1,897	2,114	17	14	11	5.7	3.6	1.2	1.1	1.8
Geothermal	3.0	8.4	20	22	51	68	77	0.4	0.2	0.4	4.2	13.1	2.8	1.3	4.8
Solar, wind, etc.	-	0.0	3.0	219	429	708	1,027	0.0	2.3	5.3	44.7	10.1	5.1	3.8	5.9
Biomass and waste	0.0	11	22	129	193	280	353	0.5	1.4	1.8	11.1	5.9	3.8	2.4	3.8

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	4,333	7,400	10,696	19,855	27,912	43,027	61,360	4.4	5.0	4.4	3.6	4.3
Population (million)	2,442	2,931	3,401	3,890	4,137	4,406	4,579	1.2	0.9	0.6	0.4	0.6
CO_2 emissions[*2] (Mt)	3,269	4,920	6,989	14,936	16,874	19,447	21,966	4.9	1.8	1.4	1.2	1.4
GDP per capita ($2010 thousand)	1.8	2.5	3.1	5.1	6.7	9.8	13	3.1	4.1	3.8	3.2	3.6
Primary energy consump. per capita (toe)	0.6	0.7	0.9	1.4	1.5	1.7	1.9	2.9	1.6	1.0	1.0	1.2
Primary energy consumption per GDP[*3]	332	285	273	272	230	176	142	-0.2	-2.4	-2.6	-2.1	-2.4
CO_2 emissions per GDP[*2, *4]	754	665	653	752	605	452	358	0.5	-3.1	-2.9	-2.3	-2.7
CO_2 per primary energy consumption[*2, *5]	2.3	2.3	2.4	2.8	2.6	2.6	2.5	0.7	-0.7	-0.2	-0.2	-0.3
Automobile ownership (million)	48	86	140	322	464	652	864	5.9	5.3	3.5	2.9	3.7
Automobile ownership rates[*6]	19	29	41	83	112	148	189	4.6	4.4	2.8	2.5	3.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A39 China [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	598	871	1,161	3,022	3,498	3,918	4,227	100	100	100	5.6	2.1	1.1	0.8	1.3
Coal	313	528	691	2,045	2,157	2,192	2,161	61	68	51	6.1	0.8	0.2	-0.1	0.2
Oil	89	119	221	478	595	704	797	14	16	19	6.2	3.2	1.7	1.2	1.9
Natural gas	12	13	21	140	256	431	580	1.5	4.6	14	11.0	9.0	5.4	3.0	5.4
Nuclear	-	-	4.4	29	117	177	237	-	1.0	5.6	n.a.	22.1	4.2	3.0	8.1
Hydro	5.0	11	19	78	100	106	110	1.3	2.6	2.6	8.9	3.6	0.5	0.4	1.3
Geothermal	-	-	1.7	4.5	6.4	8.6	10	-	0.1	0.2	n.a.	5.1	3.1	1.5	3.0
Solar, wind, etc.	-	0.0	1.0	32	48	76	109	0.0	1.1	2.6	34.9	6.0	4.7	3.7	4.7
Biomass and waste	180	200	203	216	219	224	224	23	7.1	5.3	0.3	0.2	0.2	0.0	0.1

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	494	664	815	1,814	2,106	2,381	2,604	100	100	100	4.5	2.2	1.2	0.9	1.3
Industry	188	244	329	878	960	987	997	37	48	38	5.7	1.3	0.3	0.1	0.5
Transport	24	33	88	245	321	410	489	5.0	14	19	9.1	3.9	2.5	1.8	2.6
Buildings, etc.	272	344	337	548	649	776	882	52	30	34	2.0	2.4	1.8	1.3	1.8
Non-energy use	10	43	62	143	176	208	236	6.5	7.9	9.1	5.4	3.0	1.7	1.3	1.9
Coal	220	318	304	603	611	558	496	48	33	19	2.8	0.2	-0.9	-1.2	-0.7
Oil	59	85	181	435	547	650	737	13	24	28	7.4	3.3	1.7	1.3	2.0
Natural gas	6.4	8.9	12	94	148	240	334	1.3	5.2	13	10.8	6.8	4.9	3.4	4.8
Electricity	21	39	89	386	494	617	715	5.9	21	27	10.5	3.6	2.3	1.5	2.3
Heat	7.4	13	25	76	88	94	95	2.0	4.2	3.7	7.9	2.0	0.7	0.1	0.8
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	180	200	204	220	219	222	227	30	12	8.7	0.4	-0.1	0.1	0.2	0.1

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	301	621	1,356	5,422	6,833	8,459	9,728	100	100	100	9.9	3.4	2.2	1.4	2.2
Coal	159	441	1,061	4,090	4,526	5,312	5,816	71	75	60	10.2	1.5	1.6	0.9	1.3
Oil	82	50	47	6.6	6.5	6.3	6.2	8.1	0.1	0.1	-8.5	-0.3	-0.2	-0.2	-0.2
Natural gas	0.7	2.8	5.8	99	302	608	851	0.4	1.8	8.7	16.9	17.2	7.2	3.4	8.3
Nuclear	-	-	17	112	451	681	911	-	2.1	9.4	n.a.	22.1	4.2	3.0	8.1
Hydro	58	127	222	909	1,167	1,228	1,280	20	17	13	8.9	3.6	0.5	0.4	1.3
Geothermal	-	0.1	0.1	0.1	0.3	0.3	0.4	0.0	0.0	0.0	2.9	14.6	1.5	1.4	4.7
Solar, wind, etc.	-	0.0	0.6	155	304	504	708	0.0	2.9	7.3	51.5	10.1	5.2	3.4	5.8
Biomass and waste	-	-	2.4	50	77	120	155	-	0.9	1.6	n.a.	6.3	4.5	2.6	4.3

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	334	811	2,189	7,513	11,641	19,762	29,180	10.2	6.5	5.4	4.0	5.2
Population (million)	981	1,135	1,263	1,357	1,398	1,410	1,389	0.8	0.4	0.1	-0.1	0.1
CO_2 emissions[*2] (Mt)	1,505	2,339	3,258	9,437	10,406	11,196	11,627	6.3	1.4	0.7	0.4	0.8
GDP per capita ($2010 thousand)	0.3	0.7	1.7	5.5	8.3	14	21	9.3	6.0	5.3	4.1	5.1
Primary energy consump. per capita (toe)	0.6	0.8	0.9	2.2	2.5	2.8	3.0	4.7	1.7	1.0	0.9	1.2
Primary energy consumption per GDP[*3]	1,790	1,073	530	402	300	198	145	-4.2	-4.1	-4.1	-3.1	-3.7
CO_2 emissions per GDP[*2, *4]	4,505	2,882	1,489	1,256	894	567	398	-3.5	-4.7	-4.5	-3.5	-4.2
CO_2 per primary energy consumption[*2, *5]	2.5	2.7	2.8	3.1	3.0	2.9	2.8	0.7	-0.7	-0.4	-0.4	-0.5
Automobile ownership (million)	1.2	5.3	16	127	217	309	398	14.8	8.0	3.6	2.6	4.3
Automobile ownership rates[*6]	1.2	4.7	12	93	155	219	286	13.9	7.5	3.5	2.7	4.2

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A40 India [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	200	307	441	775	993	1,360	1,830	100	100	100	4.1	3.6	3.2	3.0	3.2
Coal	45	94	146	341	428	584	806	31	44	44	5.8	3.3	3.1	3.3	3.2
Oil	33	61	112	176	248	348	451	20	23	25	4.7	5.0	3.5	2.6	3.5
Natural gas	1.3	11	23	44	69	120	196	3.4	5.7	11	6.4	6.4	5.7	5.1	5.6
Nuclear	0.8	1.6	4.4	8.9	19	49	80	0.5	1.2	4.4	7.8	11.3	10.1	5.0	8.5
Hydro	4.0	6.2	6.4	12	16	23	32	2.0	1.6	1.8	3.0	3.8	3.8	3.4	3.6
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	0.2	3.6	6.6	10	16	0.0	0.5	0.9	29.0	9.0	4.4	4.3	5.6
Biomass and waste	116	133	149	188	207	225	249	44	24	14	1.5	1.4	0.9	1.0	1.0

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	174	243	315	528	673	889	1,169	100	100	100	3.4	3.5	2.8	2.8	3.0
Industry	42	67	83	179	230	312	424	27	34	36	4.4	3.7	3.1	3.1	3.2
Transport	17	21	32	75	110	163	212	8.6	14	18	5.7	5.7	4.0	2.6	3.9
Buildings, etc.	110	142	173	238	284	344	438	59	45	37	2.3	2.6	1.9	2.4	2.3
Non-energy use	5.7	13	27	36	48	70	96	5.5	6.9	8.2	4.5	4.2	3.7	3.2	3.6
Coal	25	39	35	103	124	148	188	16	20	16	4.3	2.6	1.8	2.4	2.2
Oil	27	50	94	150	220	319	419	21	28	36	4.9	5.6	3.8	2.8	3.9
Natural gas	0.7	5.6	9.7	27	37	54	77	2.3	5.0	6.6	7.0	4.6	3.9	3.6	4.0
Electricity	7.8	18	32	77	109	180	282	7.6	14	24	6.4	5.2	5.1	4.6	5.0
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	114	130	144	172	183	189	202	54	32	17	1.2	0.9	0.3	0.7	0.6

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	120	293	570	1,193	1,675	2,714	4,196	100	100	100	6.3	5.0	4.9	4.5	4.8
Coal	61	192	390	869	1,157	1,759	2,623	65	73	63	6.8	4.2	4.3	4.1	4.2
Oil	8.8	13	29	23	23	22	20	4.5	1.9	0.5	2.4	-0.3	-0.3	-0.7	-0.5
Natural gas	0.6	10.0	56	65	131	306	619	3.4	5.5	15	8.5	10.6	8.8	7.3	8.7
Nuclear	3.0	6.1	17	34	72	189	308	2.1	2.9	7.3	7.8	11.3	10.1	5.0	8.5
Hydro	47	72	74	142	184	267	373	24	12	8.9	3.0	3.8	3.8	3.4	3.6
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	1.7	37	72	114	177	0.0	3.1	4.2	35.9	10.0	4.7	4.5	6.0
Biomass and waste	-	-	1.3	23	36	58	77	-	1.9	1.8	n.a.	6.4	4.9	2.9	4.5

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	279	479	825	2,039	3,391	6,462	11,298	6.5	7.5	6.7	5.7	6.5
Population (million)	699	869	1,042	1,252	1,359	1,495	1,599	1.6	1.2	1.0	0.7	0.9
CO_2 emissions[*2] (Mt)	265	546	901	1,894	2,480	3,459	4,757	5.6	3.9	3.4	3.2	3.5
GDP per capita ($2010 thousand)	0.4	0.6	0.8	1.6	2.5	4.3	7.1	4.8	6.3	5.6	5.0	5.6
Primary energy consump. per capita (toe)	0.3	0.4	0.4	0.6	0.7	0.9	1.1	2.5	2.4	2.2	2.3	2.3
Primary energy consumption per GDP[*3]	718	640	535	380	293	210	162	-2.2	-3.7	-3.3	-2.6	-3.1
CO_2 emissions per GDP[*2, *4]	950	1,139	1,092	929	731	535	421	-0.9	-3.4	-3.1	-2.4	-2.9
CO_2 per primary energy consumption[*2, *5]	1.3	1.8	2.0	2.4	2.5	2.5	2.6	1.4	0.3	0.2	0.2	0.2
Automobile ownership (million)	1.7	4.3	9.4	32	59	119	200	9.2	8.9	7.3	5.3	7.0
Automobile ownership rates[*6]	2.4	5.0	9.0	26	43	80	125	7.4	7.6	6.3	4.6	6.0

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A41 Japan [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	345	439	519	455	471	461	436	100	100	100	0.1	0.5	-0.2	-0.6	-0.2
Coal	60	77	97	121	118	121	116	17	27	27	2.0	-0.4	0.2	-0.4	-0.2
Oil	234	250	255	202	175	155	135	57	45	31	-0.9	-2.1	-1.2	-1.3	-1.5
Natural gas	21	44	66	106	97	110	112	10	23	26	3.9	-1.4	1.3	0.1	0.2
Nuclear	22	53	84	2.4	54	41	34	12	0.5	7.9	-12.5	56.0	-2.8	-1.7	10.3
Hydro	7.6	7.7	7.5	6.7	8.1	8.1	8.1	1.7	1.5	1.9	-0.6	2.7	0.0	0.0	0.7
Geothermal	0.8	1.6	3.1	2.4	3.8	7.7	9.0	0.4	0.5	2.1	1.9	6.9	7.1	1.6	5.0
Solar, wind, etc.	-	1.2	0.8	2.0	3.1	4.7	6.6	0.3	0.4	1.5	2.3	6.5	4.2	3.4	4.5
Biomass and waste	-	4.9	5.7	11	13	14	16	1.1	2.5	3.6	3.6	1.8	1.0	1.1	1.3

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	232	298	341	311	313	305	289	100	100	100	0.2	0.1	-0.2	-0.5	-0.3
Industry	91	101	96	82	89	89	87	34	26	30	-0.9	1.1	0.0	-0.1	0.2
Transport	54	72	88	73	70	62	55	24	24	19	0.1	-0.8	-1.1	-1.1	-1.0
Buildings, etc.	58	91	116	118	118	119	114	31	38	39	1.1	0.1	0.1	-0.5	-0.1
Non-energy use	28	34	41	38	36	35	33	12	12	11	0.4	-0.9	-0.2	-0.6	-0.5
Coal	25	32	25	26	26	25	23	11	8.3	7.9	-0.9	0.3	-0.5	-1.0	-0.5
Oil	157	182	208	166	155	137	118	61	53	41	-0.4	-1.0	-1.2	-1.5	-1.2
Natural gas	5.8	15	23	34	37	39	39	5.1	11	14	3.5	1.1	0.5	0.1	0.5
Electricity	44	64	81	82	88	95	97	22	26	34	1.0	1.1	0.7	0.3	0.7
Heat	0.1	0.2	0.5	0.5	2.6	4.7	6.5	0.1	0.2	2.3	4.5	25.1	6.0	3.4	9.6
Hydrogen	-	-	-	-	0.0	0.2	0.4	-	-	0.1	n.a.	n.a.	21.5	7.5	n.a.
Renewables	-	3.9	3.7	3.6	3.7	4.2	5.0	1.3	1.1	1.7	-0.4	0.5	1.4	1.6	1.2

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	573	836	1,049	1,038	1,116	1,188	1,200	100	100	100	0.9	1.0	0.6	0.1	0.5
Coal	55	116	229	337	318	337	325	14	32	27	4.7	-0.8	0.6	-0.4	-0.1
Oil	265	237	135	150	67	57	53	28	14	4.4	-2.0	-10.9	-1.6	-0.7	-3.8
Natural gas	81	179	256	402	343	430	452	21	39	38	3.6	-2.2	2.3	0.5	0.4
Nuclear	83	202	322	9.3	209	156	132	24	0.9	11	-12.5	56.0	-2.8	-1.7	10.3
Hydro	88	89	87	78	94	94	94	11	7.5	7.9	-0.6	2.7	0.0	0.0	0.7
Geothermal	0.9	1.7	3.3	2.6	4.3	8.7	10	0.2	0.2	0.9	1.8	7.4	7.4	1.7	5.2
Solar, wind, etc.	-	0.0	0.5	19	32	51	73	0.0	1.9	6.1	53.6	7.5	4.7	3.7	5.0
Biomass and waste	-	11	16	41	48	54	61	1.3	3.9	5.0	6.0	2.5	1.1	1.1	1.5

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	2,894	4,553	5,093	5,656	6,547	7,566	8,369	0.9	2.1	1.5	1.0	1.5
Population (million)	117	124	127	127	125	120	114	0.1	-0.2	-0.4	-0.5	-0.4
CO_2 emissions[*2] (Mt)	916	1,070	1,196	1,234	1,120	1,105	1,034	0.6	-1.4	-0.1	-0.7	-0.7
GDP per capita ($2010 thousand)	25	37	40	44	52	63	73	0.8	2.3	1.9	1.6	1.9
Primary energy consump. per capita (toe)	3.0	3.6	4.1	3.6	3.8	3.8	3.8	0.0	0.7	0.2	0.0	0.3
Primary energy consumption per GDP[*3]	119	96	102	80	72	61	52	-0.8	-1.6	-1.7	-1.6	-1.6
CO_2 emissions per GDP[*2, *4]	317	235	235	218	171	146	124	-0.3	-3.4	-1.6	-1.7	-2.1
CO_2 per primary energy consumption[*2, *5]	2.7	2.4	2.3	2.7	2.4	2.4	2.4	0.5	-1.9	0.1	-0.1	-0.5
Automobile ownership (million)	38	58	72	77	77	74	71	1.2	0.0	-0.4	-0.4	-0.3
Automobile ownership rates[*6]	325	467	571	601	611	613	623	1.1	0.2	0.0	0.2	0.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A42 Korea [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	41	93	188	264	300	328	325	100	100	100	4.6	1.9	0.9	-0.1	0.8
Coal	14	25	42	78	80	89	86	27	30	26	5.0	0.5	1.1	-0.4	0.4
Oil	27	50	99	97	100	101	98	54	37	30	2.9	0.5	0.0	-0.3	0.0
Natural gas	-	2.7	17	48	47	57	58	2.9	18	18	13.2	-0.1	1.8	0.2	0.7
Nuclear	0.9	14	28	36	66	74	74	15	14	23	4.3	8.9	1.1	0.0	2.7
Hydro	0.2	0.5	0.3	0.4	0.4	0.4	0.4	0.6	0.1	0.1	-1.7	0.0	0.0	0.0	0.0
Geothermal	-	-	-	0.1	0.1	0.1	0.1	-	0.0	0.0	n.a.	-2.8	1.9	1.6	0.6
Solar, wind, etc.	-	0.0	0.0	0.4	0.8	1.6	2.7	0.0	0.1	0.8	16.8	12.8	6.5	5.5	7.8
Biomass and waste	-	0.7	1.4	4.7	5.1	5.8	6.6	0.8	1.8	2.0	8.4	1.0	1.4	1.2	1.2

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	31	65	127	168	185	199	197	100	100	100	4.2	1.4	0.7	-0.1	0.6
Industry	10	19	38	48	55	59	58	30	28	29	4.0	2.0	0.8	-0.3	0.7
Transport	4.8	15	26	31	32	33	30	22	19	16	3.4	0.4	0.1	-0.7	-0.1
Buildings, etc.	13	24	37	45	48	53	53	38	27	27	2.7	0.8	1.0	0.0	0.6
Non-energy use	3.1	6.7	25	44	50	54	55	10	26	28	8.5	1.8	0.8	0.3	0.9
Coal	9.7	12	9.1	9.5	11	10	8.2	18	5.6	4.2	-0.9	2.2	-0.5	-2.4	-0.5
Oil	19	44	80	85	89	90	88	67	50	45	2.9	0.8	0.1	-0.2	0.1
Natural gas	-	0.7	11	24	25	28	27	1.0	14	14	16.8	0.7	1.0	-0.3	0.4
Electricity	2.8	8.1	23	42	51	62	64	13	25	33	7.4	2.9	1.9	0.5	1.6
Heat	-	-	3.3	4.3	4.0	3.8	3.5	-	2.5	1.8	n.a.	-0.9	-0.6	-0.6	-0.7
Hydrogen	-	-	-	-	0.0	0.0	0.0	-	-	0.0	n.a.	n.a.	39.3	5.7	n.a.
Renewables	-	0.7	1.3	3.5	3.9	4.4	5.1	1.1	2.1	2.6	7.0	1.4	1.4	1.4	1.4

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	37	105	289	538	647	777	812	100	100	100	7.3	2.7	1.9	0.4	1.5
Coal	2.5	18	111	223	228	279	291	17	41	36	11.7	0.3	2.0	0.4	1.0
Oil	29	19	35	21	11	8.1	6.1	18	4.0	0.8	0.6	-8.6	-3.4	-2.7	-4.5
Natural gas	-	9.6	29	145	139	183	195	9.1	27	24	12.5	-0.6	2.8	0.6	1.1
Nuclear	3.5	53	109	139	253	282	282	50	26	35	4.3	8.9	1.1	0.0	2.7
Hydro	2.0	6.4	4.0	4.3	4.3	4.3	4.3	6.0	0.8	0.5	-1.7	0.0	0.0	0.0	0.0
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	0.0	3.8	9.2	18	31	0.0	0.7	3.8	43.1	13.5	6.7	5.6	8.0
Biomass and waste	-	-	0.1	1.8	2.1	2.7	3.1	-	0.3	0.4	n.a.	2.4	2.6	1.5	2.1

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	149	377	710	1,195	1,525	1,985	2,375	5.1	3.5	2.7	1.8	2.6
Population (million)	38	43	47	50	52	53	53	0.7	0.4	0.2	0.0	0.2
CO_2 emissions[*2] (Mt)	126	239	433	582	583	631	606	3.9	0.0	0.8	-0.4	0.1
GDP per capita ($2010 thousand)	3.9	8.8	15	24	30	38	45	4.4	3.1	2.4	1.8	2.4
Primary energy consump. per capita (toe)	1.1	2.2	4.0	5.3	5.8	6.2	6.2	3.9	1.5	0.7	-0.1	0.6
Primary energy consumption per GDP[*3]	277	246	265	221	197	165	137	-0.5	-1.6	-1.7	-1.9	-1.8
CO_2 emissions per GDP[*2, *4]	845	634	610	487	383	318	255	-1.1	-3.4	-1.8	-2.2	-2.4
CO_2 per primary energy consumption[*2, *5]	3.1	2.6	2.3	2.2	1.9	1.9	1.9	-0.7	-1.8	-0.1	-0.3	-0.6
Automobile ownership (million)	0.5	3.4	12	19	22	26	29	7.9	2.0	1.6	1.0	1.5
Automobile ownership rates[*6]	14	79	257	386	433	494	546	7.1	1.6	1.3	1.0	1.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A43 Chinese Taipei [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	28	48	85	109	120	126	128	100	100	100	3.6	1.4	0.5	0.1	0.6
Coal	3.9	11	30	40	40	40	39	24	37	30	5.7	-0.1	-0.1	-0.3	-0.2
Oil	20	26	38	42	46	47	47	54	39	36	2.1	1.4	0.3	-0.2	0.4
Natural gas	1.6	1.4	5.6	13	19	27	30	2.9	12	23	10.2	5.7	3.3	1.0	3.1
Nuclear	2.1	8.6	10	11	11	8.2	8.2	18	10.0	6.4	1.0	0.0	-2.7	0.0	-1.0
Hydro	0.3	0.5	0.4	0.5	0.5	0.5	0.5	1.1	0.4	0.4	-0.7	0.0	0.0	0.0	0.0
Geothermal	-	0.0	-	-	-	-	-	0.0	-	-	-100	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	0.1	0.2	0.5	0.7	1.1	0.0	0.2	0.8	12.1	10.7	3.6	3.9	5.5
Biomass and waste	-	-	0.6	1.7	2.1	2.9	3.3	-	1.5	2.6	n.a.	3.5	3.2	1.3	2.6

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	19	29	49	68	75	81	82	100	100	100	3.7	1.6	0.7	0.2	0.7
Industry	10	12	19	23	26	27	28	42	34	34	2.8	1.5	0.7	0.2	0.7
Transport	2.9	6.6	12	12	13	14	13	22	18	16	2.6	1.1	0.4	-0.2	0.3
Buildings, etc.	3.6	6.5	10	12	13	14	14	22	17	17	2.5	1.5	0.5	0.1	0.6
Non-energy use	2.0	4.0	7.8	21	24	26	27	14	31	33	7.5	2.0	0.9	0.4	1.0
Coal	2.2	3.6	5.0	8.0	8.2	8.9	9.2	12	12	11	3.5	0.4	0.8	0.4	0.5
Oil	12	18	28	37	42	43	43	62	55	52	3.1	1.7	0.3	-0.1	0.5
Natural gas	1.4	0.9	1.6	2.5	2.8	3.4	3.8	3.0	3.7	4.7	4.7	1.7	1.8	1.3	1.6
Electricity	3.2	6.6	14	19	22	25	26	22	29	31	4.8	1.7	1.1	0.5	1.1
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	-	0.0	0.1	0.3	0.5	0.5	0.6	0.1	0.5	0.7	13.6	4.3	1.5	1.2	2.1

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	43	88	181	249	280	311	327	100	100	100	4.6	1.7	1.1	0.5	1.0
Coal	6.0	24	88	123	120	115	110	28	49	34	7.3	-0.4	-0.4	-0.4	-0.4
Oil	26	23	30	7.5	5.7	4.7	4.3	26	3.0	1.3	-4.8	-4.0	-1.9	-0.8	-2.0
Natural gas	-	1.2	17	66	98	141	157	1.4	27	48	18.8	5.8	3.7	1.1	3.3
Nuclear	8.2	33	39	42	42	32	32	37	17	9.7	1.0	0.0	-2.7	0.0	-1.0
Hydro	2.9	6.4	4.6	5.4	5.4	5.4	5.4	7.2	2.2	1.7	-0.7	0.0	0.0	0.0	0.0
Geothermal	-	0.0	-	-	-	-	-	0.0	-	-	-100	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	0.0	1.7	4.4	6.7	10	-	0.7	3.2	n.a.	14.9	4.3	4.5	7.1
Biomass and waste	-	-	1.7	3.5	5.2	7.3	8.3	-	1.4	2.6	n.a.	5.7	3.5	1.3	3.2

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	80	167	305	482	636	790	900	4.7	4.0	2.2	1.3	2.3
Population (million)	18	20	22	23	23	23	22	0.6	0.0	-0.1	-0.4	-0.2
CO_2 emissions[*2] (Mt)	74	115	225	255	272	285	282	3.5	0.9	0.5	-0.1	0.4
GDP per capita ($2010 thousand)	4.5	8.2	14	21	27	34	40	4.1	4.0	2.3	1.7	2.5
Primary energy consump. per capita (toe)	1.6	2.3	3.8	4.6	5.1	5.4	5.7	3.0	1.3	0.7	0.5	0.8
Primary energy consumption per GDP[*3]	349	286	278	226	188	160	142	-1.0	-2.6	-1.6	-1.2	-1.7
CO_2 emissions per GDP[*2, *4]	931	691	736	529	428	361	313	-1.2	-3.0	-1.7	-1.4	-1.9
CO_2 per primary energy consumption[*2, *5]	2.7	2.4	2.6	2.3	2.3	2.3	2.2	-0.1	-0.4	-0.1	-0.3	-0.2
Automobile ownership (million)	0.5	2.9	5.5	7.3	8.1	8.9	9.3	4.1	1.5	1.0	0.4	0.9
Automobile ownership rates[*6]	27	141	249	313	346	386	417	3.5	1.5	1.1	0.8	1.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A44 ASEAN [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	142	233	380	587	776	1,035	1,327	100	100	100	4.1	4.1	2.9	2.5	3.1
Coal	3.6	13	32	91	131	197	280	5.4	16	21	9.0	5.2	4.2	3.6	4.2
Oil	58	88	153	209	256	333	422	38	36	32	3.8	2.9	2.7	2.4	2.6
Natural gas	8.6	30	74	133	175	236	305	13	23	23	6.7	4.0	3.0	2.6	3.1
Nuclear	-	-	-	-	-	14	35	-	-	2.6	n.a.	n.a.	n.a.	9.3	n.a.
Hydro	0.8	2.3	4.1	9.4	12	16	18	1.0	1.6	1.4	6.2	3.7	2.5	1.4	2.4
Geothermal	1.8	6.6	18	24	67	85	96	2.8	4.2	7.3	5.8	15.5	2.4	1.2	5.2
Solar, wind, etc.	-	-	-	0.1	0.4	0.8	1.4	-	0.0	0.1	n.a.	16.2	7.2	5.6	8.9
Biomass and waste	70	93	99	118	133	150	164	40	20	12	1.0	1.7	1.2	0.9	1.2

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	112	173	271	425	532	701	897	100	100	100	4.0	3.3	2.8	2.5	2.8
Industry	22	43	76	116	153	212	279	25	27	31	4.5	4.0	3.3	2.8	3.3
Transport	17	32	62	112	140	189	250	19	26	28	5.5	3.3	3.0	2.8	3.0
Buildings, etc.	71	87	113	143	171	212	261	50	34	29	2.2	2.5	2.2	2.1	2.2
Non-energy use	2.4	11	21	53	68	87	106	6.3	13	12	7.1	3.4	2.6	2.0	2.6
Coal	2.1	6.0	13	27	34	44	54	3.5	6.4	6.0	6.7	3.4	2.6	2.0	2.6
Oil	41	67	123	194	243	319	407	38	46	45	4.8	3.3	2.8	2.5	2.8
Natural gas	2.5	7.5	17	40	56	80	106	4.4	9.4	12	7.5	4.9	3.6	2.9	3.7
Electricity	4.7	11	28	61	87	137	201	6.4	14	22	7.7	5.2	4.6	3.9	4.5
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	62	82	90	103	111	121	129	47	24	14	1.0	1.2	0.9	0.6	0.9

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	62	154	370	786	1,117	1,738	2,538	100	100	100	7.3	5.1	4.5	3.9	4.4
Coal	3.0	28	79	255	383	639	1,003	18	32	40	10.1	6.0	5.3	4.6	5.2
Oil	47	66	72	43	38	37	36	43	5.5	1.4	-1.8	-1.9	-0.1	-0.3	-0.7
Natural gas	0.7	26	154	349	480	720	1,025	17	44	40	11.9	4.7	4.1	3.6	4.1
Nuclear	-	-	-	-	-	55	133	-	-	5.2	n.a.	n.a.	n.a.	9.3	n.a.
Hydro	9.8	27	47	109	141	181	209	18	14	8.2	6.2	3.7	2.5	1.4	2.4
Geothermal	2.1	6.6	16	19	46	58	65	4.3	2.4	2.6	4.7	13.5	2.3	1.2	4.7
Solar, wind, etc.	-	-	-	1.7	4.9	9.8	17	-	0.2	0.7	n.a.	16.2	7.2	5.6	8.9
Biomass and waste	-	0.6	1.0	10	24	38	50	0.4	1.3	2.0	13.0	13.5	4.6	2.6	6.1

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	405	703	1,137	2,190	3,097	4,848	7,019	5.1	5.1	4.6	3.8	4.4
Population (million)	345	427	503	594	640	693	732	1.4	1.1	0.8	0.5	0.8
CO_2 emissions[*2] (Mt)	205	362	710	1,162	1,519	2,102	2,814	5.2	3.9	3.3	3.0	3.3
GDP per capita ($2010 thousand)	1.2	1.6	2.3	3.7	4.8	7.0	9.6	3.6	4.0	3.7	3.2	3.6
Primary energy consump. per capita (toe)	0.4	0.5	0.8	1.0	1.2	1.5	1.8	2.6	3.0	2.1	2.0	2.3
Primary energy consumption per GDP[*3]	352	332	334	268	251	214	189	-0.9	-0.9	-1.6	-1.2	-1.3
CO_2 emissions per GDP[*2, *4]	507	515	624	531	491	434	401	0.1	-1.1	-1.2	-0.8	-1.0
CO_2 per primary energy consumption[*2, *5]	1.4	1.6	1.9	2.0	2.0	2.0	2.1	1.1	-0.2	0.4	0.4	0.3
Automobile ownership (million)	4.4	10	21	52	70	98	133	7.4	4.4	3.4	3.2	3.6
Automobile ownership rates[*6]	13	24	41	87	110	141	182	5.9	3.3	2.5	2.6	2.8

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A45 Indonesia [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	56	99	156	214	314	419	540	100	100	100	3.4	5.6	2.9	2.6	3.5
Coal	0.2	3.5	12	32	54	86	126	3.6	15	23	10.0	8.0	4.8	3.9	5.3
Oil	20	33	58	77	93	119	155	34	36	29	3.7	2.8	2.5	2.6	2.6
Natural gas	4.9	16	27	33	51	73	99	16	15	18	3.2	6.5	3.6	3.1	4.2
Nuclear	-	-	-	-	-	2.6	7.7	-	-	1.4	n.a.	n.a.	n.a.	11.6	n.a.
Hydro	0.1	0.5	0.9	1.5	1.6	1.8	1.9	0.5	0.7	0.4	4.8	1.3	1.3	0.7	1.1
Geothermal	-	1.9	8.4	16	54	71	80	2.0	7.6	15	9.7	18.9	2.7	1.2	6.1
Solar, wind, etc.	-	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0	n.a.	30.1	6.3	6.4	12.1
Biomass and waste	30	43	50	55	59	66	71	44	26	13	1.0	1.1	1.0	0.7	0.9

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	50	80	121	162	205	269	351	100	100	100	3.1	3.4	2.8	2.7	2.9
Industry	6.7	18	31	37	51	74	102	23	23	29	3.1	4.9	3.7	3.2	3.8
Transport	6.0	11	22	46	61	85	117	13	29	33	6.6	4.0	3.4	3.3	3.5
Buildings, etc.	36	44	59	68	79	96	115	55	42	33	1.9	2.2	1.9	1.9	2.0
Non-energy use	1.2	7.4	9.8	11	13	15	17	9.2	6.8	4.9	1.8	2.6	1.3	1.4	1.7
Coal	0.1	2.2	4.7	4.6	8.0	12	15	2.7	2.8	4.4	3.3	8.2	3.8	2.9	4.6
Oil	17	27	49	70	88	115	150	34	43	43	4.2	3.4	2.6	2.7	2.9
Natural gas	2.4	6.0	12	17	24	35	49	7.5	11	14	4.7	4.8	3.8	3.6	4.0
Electricity	0.6	2.4	6.8	16	26	43	66	3.0	10	19	8.6	7.0	5.2	4.4	5.3
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	29	42	49	54	58	65	69	53	33	20	1.1	1.1	1.0	0.7	0.9

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	7.5	33	93	216	345	570	871	100	100	100	8.6	7.0	5.1	4.3	5.3
Coal	-	9.8	34	110	176	308	492	30	51	57	11.1	6.9	5.7	4.8	5.7
Oil	6.2	15	18	27	23	23	22	47	12	2.6	2.4	-2.0	-0.2	-0.2	-0.7
Natural gas	-	0.7	26	52	95	167	256	2.2	24	29	20.3	9.1	5.8	4.4	6.1
Nuclear	-	-	-	-	-	9.8	29	-	-	3.4	n.a.	n.a.	n.a.	11.6	n.a.
Hydro	1.3	5.7	10	17	19	21	23	17	7.9	2.6	4.8	1.3	1.3	0.7	1.1
Geothermal	-	1.1	4.9	9.4	32	41	47	3.4	4.4	5.3	9.7	18.9	2.7	1.2	6.1
Solar, wind, etc.	-	-	-	0.0	0.0	0.1	0.1	-	0.0	0.0	n.a.	30.3	6.3	6.4	12.1
Biomass and waste	-	-	0.0	0.3	0.5	0.8	1.1	-	0.1	0.1	n.a.	9.9	4.9	2.9	5.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	152	282	426	849	1,247	2,015	3,041	4.9	5.6	4.9	4.2	4.8
Population (million)	145	179	209	250	270	294	311	1.5	1.1	0.8	0.6	0.8
CO_2 emissions[*2] (Mt)	71	134	262	406	582	836	1,158	4.9	5.3	3.7	3.3	4.0
GDP per capita ($2010 thousand)	1.0	1.6	2.0	3.4	4.6	6.9	9.8	3.4	4.5	4.0	3.6	4.0
Primary energy consump. per capita (toe)	0.4	0.6	0.7	0.9	1.2	1.4	1.7	1.9	4.5	2.1	2.0	2.7
Primary energy consumption per GDP[*3]	367	350	365	252	252	208	178	-1.4	0.0	-1.9	-1.6	-1.3
CO_2 emissions per GDP[*2, *4]	471	475	615	478	467	415	381	0.0	-0.3	-1.2	-0.8	-0.8
CO_2 per primary energy consumption[*2, *5]	1.3	1.4	1.7	1.9	1.9	2.0	2.1	1.5	-0.3	0.7	0.7	0.4
Automobile ownership (million)	1.3	2.8	5.4	19	29	44	62	8.8	6.1	4.1	3.7	4.4
Automobile ownership rates[*6]	8.9	16	26	78	108	148	201	7.2	4.9	3.2	3.1	3.6

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A46 Malaysia [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	12	22	49	89	109	135	160	100	100	100	6.2	3.0	2.1	1.7	2.2
Coal	0.1	1.4	2.3	15	20	26	32	6.1	17	20	11.1	3.6	2.7	2.1	2.7
Oil	7.9	11	19	31	38	46	52	51	35	33	4.5	3.0	1.9	1.3	2.0
Natural gas	2.2	6.8	25	38	44	51	57	31	43	36	7.8	2.1	1.5	1.2	1.5
Nuclear	-	-	-	-	-	2.6	7.7	-	-	4.8	n.a.	n.a.	n.a.	11.6	n.a.
Hydro	0.1	0.3	0.6	0.9	1.2	1.8	2.4	1.5	1.0	1.5	4.3	4.2	3.7	3.1	3.6
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	-	0.0	0.0	0.1	0.1	-	0.0	0.1	n.a.	16.9	9.0	4.8	9.4
Biomass and waste	1.8	2.3	2.8	3.7	6.0	7.5	8.4	10	4.1	5.3	2.0	7.3	2.2	1.2	3.1

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	7.2	14	30	54	69	87	103	100	100	100	6.1	3.5	2.3	1.8	2.4
Industry	3.1	5.6	12	15	20	25	30	40	28	29	4.5	4.1	2.3	1.8	2.6
Transport	2.1	4.8	10	19	23	27	30	34	36	29	6.3	2.5	1.6	1.0	1.6
Buildings, etc.	1.8	2.8	5.4	10	14	20	27	20	19	26	5.7	4.9	3.6	2.7	3.6
Non-energy use	0.3	0.8	2.2	9.2	11	14	17	6.0	17	16	11.0	3.1	2.1	1.8	2.2
Coal	0.1	0.5	1.0	1.5	2.1	2.5	2.8	3.7	2.8	2.7	4.9	4.5	1.8	1.1	2.3
Oil	5.3	9.2	18	28	35	42	48	66	51	47	4.9	3.3	2.0	1.3	2.1
Natural gas	0.0	1.1	3.9	12	15	18	21	7.8	22	21	11.0	3.3	1.9	1.5	2.1
Electricity	0.7	1.7	5.3	11	15	21	29	12	20	28	8.4	4.2	3.8	3.1	3.7
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	1.1	1.5	1.7	2.0	2.5	2.5	2.4	11	3.6	2.3	1.3	3.2	0.3	-0.6	0.7

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	10	23	69	138	185	267	363	100	100	100	8.1	4.2	3.7	3.1	3.6
Coal	-	2.9	7.7	53	70	98	127	13	39	35	13.4	4.1	3.3	2.7	3.3
Oil	8.5	11	3.6	5.3	6.2	6.8	6.6	46	3.9	1.8	-2.9	2.1	1.0	-0.3	0.8
Natural gas	0.1	5.5	51	68	89	124	161	24	49	44	11.5	4.1	3.3	2.7	3.3
Nuclear	-	-	-	-	-	9.8	29	-	-	8.1	n.a.	n.a.	n.a.	11.6	n.a.
Hydro	1.4	4.0	7.0	11	14	20	28	17	7.7	7.7	4.3	4.2	3.7	3.1	3.6
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	-	0.1	0.4	1.0	1.6	-	0.1	0.4	n.a.	16.9	9.0	4.8	9.4
Biomass and waste	-	-	-	1.1	4.1	6.7	8.9	-	0.8	2.4	n.a.	20.1	4.9	2.9	7.9

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	44	79	158	288	408	633	872	5.8	5.1	4.5	3.3	4.2
Population (million)	14	18	23	30	33	36	39	2.2	1.4	1.1	0.7	1.0
CO_2 emissions[*2] (Mt)	29	54	120	222	269	327	377	6.3	2.8	2.0	1.4	2.0
GDP per capita ($2010 thousand)	3.2	4.4	6.7	9.7	13	17	22	3.5	3.7	3.4	2.5	3.1
Primary energy consump. per capita (toe)	0.9	1.2	2.1	3.0	3.3	3.7	4.1	4.0	1.6	1.0	1.0	1.1
Primary energy consumption per GDP[*3]	272	279	314	309	267	213	183	0.4	-2.0	-2.3	-1.5	-1.9
CO_2 emissions per GDP[*2, *4]	649	681	761	771	660	517	433	0.5	-2.2	-2.4	-1.8	-2.1
CO_2 per primary energy consumption[*2, *5]	2.4	2.4	2.4	2.5	2.5	2.4	2.4	0.1	-0.2	-0.2	-0.3	-0.2
Automobile ownership (million)	0.9	2.4	5.2	12	15	19	22	7.3	3.3	2.0	1.4	2.1
Automobile ownership rates[*6]	65	133	224	414	472	516	549	5.0	1.9	0.9	0.6	1.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A47 Myanmar [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	9.4	11	13	17	20	26	33	100	100	100	1.9	2.7	2.5	2.5	2.6
Coal	0.2	0.1	0.3	0.4	0.7	1.4	2.3	0.6	2.2	7.1	7.7	10.5	6.7	5.0	7.0
Oil	1.3	0.7	2.0	2.8	3.7	5.6	8.7	6.8	17	27	6.0	4.3	4.2	4.5	4.3
Natural gas	0.3	0.8	1.2	1.8	3.4	5.6	8.0	7.1	11	24	3.9	9.1	5.2	3.6	5.6
Nuclear	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydro	0.1	0.1	0.2	0.8	0.9	1.3	1.7	1.0	4.6	5.2	9.1	3.0	3.0	3.0	3.0
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	-	-	0.0	0.0	0.0	-	-	0.1	n.a.	n.a.	6.0	6.3	n.a.
Biomass and waste	7.6	9.0	9.2	11	11	12	12	84	65	37	0.8	0.5	0.4	0.3	0.4

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	8.4	9.4	11	15	17	22	28	100	100	100	2.1	2.0	2.2	2.4	2.2
Industry	0.6	0.4	1.2	1.9	2.6	4.0	6.2	4.2	12	23	7.1	4.7	4.5	4.4	4.5
Transport	0.6	0.4	1.2	1.4	2.0	3.5	6.0	4.7	9.0	22	5.0	5.7	5.7	5.5	5.6
Buildings, etc.	7.0	8.5	9.1	12	13	14	15	90	77	55	1.4	1.0	0.9	0.9	0.9
Non-energy use	0.1	0.1	0.1	0.3	0.3	0.3	0.3	1.0	1.7	1.2	4.5	1.0	1.0	1.0	1.0
Coal	0.1	0.1	0.3	0.2	0.3	0.5	0.7	0.5	1.6	2.5	7.1	3.9	3.9	3.9	3.9
Oil	1.2	0.6	1.5	2.7	3.6	5.5	8.6	6.2	18	31	6.9	4.2	4.3	4.6	4.4
Natural gas	0.1	0.2	0.3	0.8	1.0	1.4	1.9	2.4	5.1	6.8	5.5	3.5	3.4	3.1	3.3
Electricity	0.1	0.1	0.3	0.7	1.4	2.6	4.4	1.6	4.9	16	7.3	9.2	6.6	5.3	6.7
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	6.9	8.4	9.0	11	11	12	12	89	71	44	1.1	0.5	0.4	0.3	0.4

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1.5	2.5	5.1	12	22	40	65	100	100	100	7.1	8.9	6.3	5.0	6.5
Coal	0.0	0.0	-	0.5	1.8	4.2	7.6	1.6	4.3	12	11.7	19.6	8.9	6.0	10.5
Oil	0.5	0.3	0.7	0.1	0.1	0.1	0.1	11	0.5	0.1	-6.7	0.0	0.0	0.0	0.0
Natural gas	0.2	1.0	2.5	2.4	8.7	21	37	39	21	57	4.1	19.9	9.0	6.0	10.6
Nuclear	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydro	0.8	1.2	1.9	8.9	11	15	20	48	75	31	9.1	3.0	3.0	3.0	3.0
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	-	-	0.1	0.2	0.3	-	-	0.5	n.a.	n.a.	6.0	6.3	n.a.
Biomass and waste	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	5.9	6.7	13	51	87	156	248	9.2	8.0	6.0	4.8	6.1
Population (million)	34	42	48	53	57	61	63	1.0	0.9	0.7	0.4	0.6
CO_2 emissions[*2] (Mt)	5.2	4.1	9.9	14	22	35	54	5.4	6.8	5.0	4.3	5.2
GDP per capita ($2010 thousand)	0.2	0.2	0.3	1.0	1.5	2.6	3.9	8.1	7.1	5.3	4.3	5.4
Primary energy consump. per capita (toe)	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.9	1.9	1.8	2.1	1.9
Primary energy consumption per GDP[*3]	1,603	1,599	964	327	230	164	132	-6.7	-4.9	-3.3	-2.2	-3.3
CO_2 emissions per GDP[*2, *4]	891	608	744	269	249	226	217	-3.5	-1.1	-0.9	-0.4	-0.8
CO_2 per primary energy consumption[*2, *5]	0.6	0.4	0.8	0.8	1.1	1.4	1.6	3.4	4.0	2.5	1.8	2.6
Automobile ownership (million)	0.1	0.1	0.3	0.5	0.9	1.8	3.4	9.3	7.4	7.2	6.9	7.2
Automobile ownership rates[*6]	2.2	1.6	5.2	10.0	15	29	54	8.2	6.5	6.5	6.5	6.5

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A48 Philippines [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	22	29	40	45	58	76	99	100	100	100	1.9	3.7	2.8	2.6	3.0
Coal	0.5	1.5	5.2	11	13	19	27	5.3	24	28	8.9	2.3	4.2	3.5	3.5
Oil	10	11	16	14	19	26	34	38	30	35	1.0	4.7	3.2	2.9	3.5
Natural gas	-	-	0.0	2.9	4.6	7.4	11	-	6.5	11	n.a.	6.7	4.9	3.8	4.9
Nuclear	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydro	0.3	0.5	0.7	0.9	1.0	1.0	1.0	1.8	1.9	1.0	2.2	1.9	0.0	0.0	0.5
Geothermal	1.8	4.7	10.0	8.3	13	14	16	16	19	16	2.5	6.1	1.4	1.2	2.5
Solar, wind, etc.	-	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0	n.a.	14.6	6.2	4.0	7.5
Biomass and waste	9.4	11	8.1	8.2	8.0	8.4	9.3	39	18	9.4	-1.3	-0.4	0.5	1.1	0.5

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	17	20	24	26	33	44	57	100	100	100	1.2	3.4	2.9	2.8	3.0
Industry	3.4	4.7	5.3	6.9	8.6	11	14	24	27	25	1.7	3.2	2.6	2.4	2.7
Transport	3.5	4.5	8.1	8.8	12	17	24	23	34	42	2.9	4.4	3.7	3.4	3.8
Buildings, etc.	9.4	10	10	9.8	12	15	19	52	38	32	-0.2	2.6	2.3	2.3	2.4
Non-energy use	0.3	0.2	0.3	0.3	0.4	0.6	0.8	1.2	1.2	1.4	1.4	4.4	3.4	3.1	3.6
Coal	0.2	0.6	0.8	2.1	1.8	1.4	1.1	3.1	8.3	1.9	5.6	-2.3	-2.3	-2.8	-2.5
Oil	7.0	8.1	13	12	17	24	32	41	47	56	1.8	4.8	3.4	3.0	3.7
Natural gas	-	-	-	0.1	0.5	1.0	1.5	-	0.2	2.6	n.a.	33.0	7.8	4.4	12.5
Electricity	1.5	1.8	3.1	5.3	7.3	11	15	9.3	21	26	4.7	4.7	3.9	3.3	3.9
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	7.8	9.1	6.9	6.1	6.1	6.7	7.7	46	24	13	-1.7	0.1	0.9	1.4	0.9

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	18	26	45	75	104	150	206	100	100	100	4.7	4.7	3.8	3.2	3.8
Coal	0.2	1.9	17	32	47	76	112	7.3	43	54	13.0	5.5	5.0	3.9	4.7
Oil	12	12	9.2	4.5	4.1	3.6	3.1	47	6.0	1.5	-4.3	-1.2	-1.3	-1.5	-1.3
Natural gas	-	-	0.0	19	26	41	59	-	25	29	n.a.	4.8	4.6	3.7	4.3
Nuclear	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydro	3.5	6.1	7.8	10	11	11	11	23	13	5.5	2.2	1.9	0.0	0.0	0.5
Geothermal	2.1	5.5	12	9.6	15	17	19	21	13	9.2	2.5	6.1	1.4	1.2	2.5
Solar, wind, etc.	-	-	-	0.1	0.2	0.3	0.5	-	0.1	0.2	n.a.	14.6	6.2	4.0	7.5
Biomass and waste	-	0.4	-	0.2	0.4	0.7	0.9	1.6	0.3	0.4	-3.0	10.0	4.9	2.9	5.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	80	95	125	237	360	563	838	4.1	6.2	4.6	4.0	4.8
Population (million)	47	62	78	98	109	125	138	2.0	1.5	1.3	1.0	1.3
CO_2 emissions[*2] (Mt)	33	39	69	90	117	171	235	3.8	3.8	3.8	3.3	3.6
GDP per capita ($2010 thousand)	1.7	1.5	1.6	2.4	3.3	4.5	6.1	2.0	4.6	3.2	3.0	3.5
Primary energy consump. per capita (toe)	0.5	0.5	0.5	0.5	0.5	0.6	0.7	-0.1	2.1	1.5	1.6	1.7
Primary energy consumption per GDP[*3]	280	304	319	188	160	135	118	-2.1	-2.3	-1.7	-1.4	-1.7
CO_2 emissions per GDP[*2, *4]	414	409	550	382	326	303	281	-0.3	-2.2	-0.7	-0.7	-1.1
CO_2 per primary energy consumption[*2, *5]	1.5	1.3	1.7	2.0	2.0	2.2	2.4	1.8	0.1	0.9	0.6	0.6
Automobile ownership (million)	0.9	1.2	2.4	3.4	5.1	8.6	14	4.6	6.0	5.4	5.1	5.4
Automobile ownership rates[*6]	18	20	31	35	47	69	103	2.5	4.4	4.0	4.0	4.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A49 Thailand [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total*1	22	42	72	134	159	202	244	100	100	100	5.2	2.4	2.5	1.9	2.2
Coal	0.5	3.8	7.7	17	20	25	31	9.1	13	13	6.8	1.9	2.6	2.0	2.2
Oil	11	18	32	53	62	78	92	43	39	38	4.8	2.4	2.2	1.7	2.1
Natural gas	-	5.0	17	38	44	56	66	12	28	27	9.2	2.3	2.4	1.6	2.1
Nuclear	-	-	-	-	-	2.6	7.7	-	-	3.1	n.a.	n.a.	n.a.	11.6	n.a.
Hydro	0.1	0.4	0.5	0.5	0.5	0.5	0.6	1.0	0.4	0.2	0.6	0.5	0.5	0.5	0.5
Geothermal	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4	1.5	1.3	5.8
Solar, wind, etc.	-	-	-	0.1	0.3	0.6	1.0	-	0.1	0.4	n.a.	15.0	6.9	4.7	8.1
Biomass and waste	11	15	15	25	30	37	42	35	18	17	2.3	2.9	2.0	1.4	2.0

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	15	29	51	96	115	144	173	100	100	100	5.4	2.6	2.3	1.8	2.2
Industry	4.0	8.7	17	30	35	45	55	30	31	32	5.5	2.4	2.5	2.0	2.3
Transport	3.2	9.0	15	23	25	27	27	31	24	16	4.1	1.4	0.6	0.3	0.7
Buildings, etc.	7.8	11	14	21	26	33	40	37	22	23	3.0	2.6	2.4	2.1	2.4
Non-energy use	0.2	0.4	5.6	22	29	40	50	1.5	23	29	18.6	4.0	3.4	2.3	3.2
Coal	0.1	1.3	3.5	8.7	9.3	11	12	4.5	9.1	6.9	8.6	0.9	1.5	1.0	1.2
Oil	7.3	15	29	50	60	75	88	52	53	51	5.4	2.5	2.3	1.7	2.1
Natural gas	-	0.1	1.1	7.1	10.0	14	18	0.5	7.4	10	18.7	4.9	3.4	2.3	3.4
Electricity	1.1	3.3	7.6	14	17	25	33	11	15	19	6.5	3.0	3.6	3.0	3.2
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	6.7	9.2	9.4	15	18	20	22	32	16	13	2.3	2.4	1.0	0.7	1.2

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	14	44	96	166	201	280	367	100	100	100	5.9	2.8	3.4	2.7	3.0
Coal	1.4	11	18	33	42	61	84	25	20	23	4.9	3.4	4.0	3.1	3.5
Oil	12	10	10	1.7	1.6	1.6	1.5	23	1.0	0.4	-7.6	-0.4	-0.4	-0.5	-0.5
Natural gas	-	18	62	117	135	172	206	40	71	56	8.5	2.0	2.5	1.8	2.1
Nuclear	-	-	-	-	-	9.8	29	-	-	8.0	n.a.	n.a.	n.a.	11.6	n.a.
Hydro	1.3	5.0	6.0	5.7	6.0	6.3	6.6	11	3.5	1.8	0.6	0.5	0.5	0.5	0.5
Geothermal	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4	1.5	1.3	5.8
Solar, wind, etc.	-	-	-	1.4	3.7	7.2	11	-	0.8	3.1	n.a.	15.0	6.9	4.7	8.1
Biomass and waste	-	-	0.5	7.0	14	22	29	-	4.2	7.9	n.a.	10.0	4.9	2.9	5.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	63	135	209	350	444	637	866	4.2	3.5	3.7	3.1	3.4
Population (million)	47	57	62	67	68	68	66	0.7	0.2	0.0	-0.3	-0.1
CO_2 emissions*2 (Mt)	34	81	152	254	288	352	411	5.1	1.8	2.0	1.6	1.8
GDP per capita ($2010 thousand)	1.3	2.4	3.3	5.2	6.5	9.4	13	3.5	3.2	3.7	3.4	3.5
Primary energy consump. per capita (toe)	0.5	0.7	1.2	2.0	2.3	3.0	3.7	4.4	2.2	2.5	2.2	2.3
Primary energy consumption per GDP*3	347	311	346	383	358	317	282	0.9	-1.0	-1.2	-1.2	-1.1
CO_2 emissions per GDP*2, *4	537	598	727	726	648	552	474	0.8	-1.6	-1.6	-1.5	-1.6
CO_2 per primary energy consumption*2, *5	1.5	1.9	2.1	1.9	1.8	1.7	1.7	-0.1	-0.6	-0.4	-0.4	-0.4
Automobile ownership (million)	0.9	2.8	6.1	14	16	19	22	7.2	2.0	1.8	1.5	1.7
Automobile ownership rates*6	19	50	98	208	235	281	336	6.4	1.8	1.8	1.8	1.8

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A50 Viet Nam [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	14	18	29	60	83	136	206	100	100	100	5.4	4.7	5.1	4.2	4.7
Coal	2.3	2.2	4.4	16	23	38	61	12	26	30	8.9	5.8	5.0	4.8	5.2
Oil	1.8	2.7	7.8	16	21	37	56	15	26	27	7.9	4.4	5.7	4.4	4.9
Natural gas	-	0.0	1.1	8.4	15	29	49	0.0	14	24	41.9	8.8	6.7	5.4	6.7
Nuclear	-	-	-	-	-	6.6	12	-	-	5.7	n.a.	n.a.	n.a.	5.9	n.a.
Hydro	0.1	0.5	1.3	4.9	6.9	9.2	10	2.6	8.2	5.0	10.8	5.0	2.9	1.2	2.8
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	-	0.0	0.0	0.0	0.1	-	0.0	0.1	n.a.	15.1	8.2	9.0	10.2
Biomass and waste	10	12	14	15	16	16	17	70	25	8.2	0.9	0.6	0.4	0.3	0.4

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	13	16	25	51	68	105	151	100	100	100	5.2	4.1	4.5	3.7	4.1
Industry	3.8	4.5	7.9	19	28	44	63	28	38	42	6.5	5.2	4.8	3.6	4.4
Transport	0.6	1.4	3.5	10	14	26	42	8.6	20	27	9.2	4.5	6.4	4.7	5.3
Buildings, etc.	8.6	10	14	19	23	31	41	63	38	27	2.9	2.7	2.7	3.0	2.8
Non-energy use	0.0	0.0	0.1	1.7	2.4	3.9	5.8	0.2	3.3	3.9	19.6	4.8	5.3	4.0	4.7
Coal	1.5	1.3	3.2	9.7	12	17	22	8.3	19	14	9.0	3.7	3.2	2.4	3.0
Oil	1.7	2.3	6.5	16	21	37	57	15	31	37	8.7	4.3	5.6	4.4	4.8
Natural gas	-	-	0.0	1.3	3.1	7.0	11	-	2.6	7.0	n.a.	12.5	8.5	4.2	7.9
Electricity	0.2	0.5	1.9	9.8	16	29	47	3.3	19	31	13.5	7.0	6.1	5.0	5.9
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	9.7	12	13	14	15	15	16	74	28	11	0.8	0.6	0.4	0.3	0.4

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	3.6	8.7	27	127	201	361	587	100	100	100	12.4	6.8	6.0	5.0	5.8
Coal	1.4	2.0	3.1	25	46	92	179	23	20	31	11.6	9.0	7.3	6.9	7.6
Oil	0.7	1.3	4.5	2.3	2.3	2.3	2.3	15	1.8	0.4	2.4	0.0	0.0	0.0	0.0
Natural gas	-	0.0	4.4	43	73	134	239	0.1	34	41	47.1	8.0	6.3	5.9	6.6
Nuclear	-	-	-	-	-	25	45	-	-	7.6	n.a.	n.a.	n.a.	5.9	n.a.
Hydro	1.5	5.4	15	57	80	107	120	62	45	21	10.8	5.0	2.9	1.2	2.8
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	-	-	0.1	0.2	0.5	1.2	-	0.1	0.2	n.a.	15.1	8.2	9.0	10.2
Biomass and waste	-	-	-	0.1	0.1	0.2	0.2	-	0.0	0.0	n.a.	9.0	4.9	2.9	5.2

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	17	29	61	137	205	388	631	6.9	6.0	6.6	5.0	5.8
Population (million)	54	66	78	90	96	103	108	1.3	1.0	0.7	0.4	0.7
CO_2 emissions[*2] (Mt)	15	17	43	125	185	319	512	9.0	5.9	5.6	4.8	5.4
GDP per capita ($2010 thousand)	0.3	0.4	0.8	1.5	2.1	3.8	5.8	5.5	4.9	5.8	4.5	5.1
Primary energy consump. per capita (toe)	0.3	0.3	0.4	0.7	0.9	1.3	1.9	4.0	3.6	4.4	3.8	4.0
Primary energy consumption per GDP[*3]	851	606	470	439	403	352	327	-1.4	-1.2	-1.3	-0.7	-1.1
CO_2 emissions per GDP[*2, *4]	860	579	711	911	905	824	811	2.0	-0.1	-0.9	-0.1	-0.4
CO_2 per primary energy consumption[*2, *5]	1.0	1.0	1.5	2.1	2.2	2.3	2.5	3.4	1.1	0.4	0.6	0.7
Automobile ownership (million)	0.2	0.2	0.4	1.3	2.2	4.5	8.1	9.1	7.9	7.5	6.1	7.1
Automobile ownership rates[*6]	2.9	2.6	4.8	14	22	43	75	7.6	6.8	6.8	5.7	6.4

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A51 North America [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,997	2,124	2,525	2,442	2,519	2,538	2,463	100	100	100	0.6	0.4	0.1	-0.3	0.0
Coal	397	485	565	450	417	345	269	23	18	11	-0.3	-1.1	-1.9	-2.5	-1.9
Oil	885	833	958	859	865	854	792	39	35	32	0.1	0.1	-0.1	-0.8	-0.3
Natural gas	522	493	622	697	759	826	850	23	29	35	1.5	1.2	0.8	0.3	0.7
Nuclear	80	179	227	241	243	238	246	8.4	9.9	10.0	1.3	0.1	-0.2	0.3	0.1
Hydro	46	49	53	57	60	63	64	2.3	2.3	2.6	0.7	0.6	0.5	0.3	0.5
Geothermal	4.6	14	13	8.6	19	24	30	0.7	0.4	1.2	-2.1	12.1	2.2	2.3	4.7
Solar, wind, etc.	-	0.3	2.1	19	30	51	66	0.0	0.8	2.7	19.3	7.3	5.3	2.6	4.8
Biomass and waste	62	70	85	111	125	137	146	3.3	4.5	5.9	2.0	1.7	0.9	0.6	1.0

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,466	1,452	1,736	1,694	1,752	1,785	1,740	100	100	100	0.7	0.5	0.2	-0.3	0.1
Industry	437	331	387	309	318	314	303	23	18	17	-0.3	0.4	-0.1	-0.4	-0.1
Transport	470	531	640	669	684	679	634	37	39	36	1.0	0.3	-0.1	-0.7	-0.2
Buildings, etc.	446	457	535	573	597	619	623	31	34	36	1.0	0.6	0.4	0.1	0.3
Non-energy use	114	134	173	143	153	173	180	9.2	8.4	10	0.3	1.0	1.2	0.4	0.9
Coal	60	59	36	26	27	24	21	4.0	1.5	1.2	-3.6	1.0	-1.1	-1.5	-0.7
Oil	769	752	874	826	827	820	764	52	49	44	0.4	0.0	-0.1	-0.7	-0.3
Natural gas	374	346	413	380	394	397	394	24	22	23	0.4	0.5	0.1	-0.1	0.1
Electricity	200	262	342	367	402	436	451	18	22	26	1.5	1.3	0.8	0.3	0.8
Heat	1.0	2.8	6.1	6.5	7.0	6.9	6.7	0.2	0.4	0.4	3.8	1.1	-0.2	-0.3	0.1
Hydrogen	-	-	-	-	0.0	0.0	0.0	-	-	0.0	n.a.	n.a.	35.5	6.9	n.a.
Renewables	62	30	64	89	95	100	103	2.1	5.3	5.9	4.8	1.0	0.5	0.3	0.5

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,801	3,685	4,631	4,939	5,381	5,811	5,999	100	100	100	1.3	1.2	0.8	0.3	0.7
Coal	1,303	1,782	2,247	1,778	1,675	1,422	1,128	48	36	19	0.0	-0.8	-1.6	-2.3	-1.7
Oil	277	147	133	44	40	32	21	4.0	0.9	0.4	-5.1	-1.5	-2.3	-4.0	-2.7
Natural gas	380	391	668	1,226	1,548	1,940	2,170	11	25	36	5.1	3.4	2.3	1.1	2.1
Nuclear	304	685	871	925	931	915	942	19	19	16	1.3	0.1	-0.2	0.3	0.1
Hydro	530	570	612	663	693	727	749	15	13	12	0.7	0.6	0.5	0.3	0.5
Geothermal	5.4	16	15	18	41	50	64	0.4	0.4	1.1	0.6	11.9	2.2	2.4	4.7
Solar, wind, etc.	-	3.8	6.7	202	336	571	738	0.1	4.1	12	18.9	7.6	5.5	2.6	4.9
Biomass and waste	1.8	90	80	84	117	154	187	2.5	1.7	3.1	-0.3	5.0	2.8	1.9	3.0

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	7,291	10,064	14,050	17,619	20,910	26,405	31,603	2.5	2.5	2.4	1.8	2.2
Population (million)	252	277	313	351	370	395	415	1.0	0.7	0.7	0.5	0.6
CO_2 emissions[*2] (Mt)	5,169	5,236	6,125	5,626	5,632	5,414	4,962	0.3	0.0	-0.4	-0.9	-0.5
GDP per capita ($2010 thousand)	29	36	45	50	57	67	76	1.4	1.7	1.7	1.3	1.6
Primary energy consump. per capita (toe)	7.9	7.7	8.1	7.0	6.8	6.4	5.9	-0.4	-0.3	-0.6	-0.8	-0.6
Primary energy consumption per GDP[*3]	274	211	180	139	120	96	78	-1.8	-2.0	-2.2	-2.1	-2.1
CO_2 emissions per GDP[*2, *4]	709	520	436	319	269	205	157	-2.1	-2.4	-2.7	-2.6	-2.6
CO_2 per primary energy consumption[*2, *5]	2.6	2.5	2.4	2.3	2.2	2.1	2.0	-0.3	-0.4	-0.5	-0.6	-0.5
Automobile ownership (million)	169	205	239	275	296	328	352	1.3	1.1	1.0	0.7	0.9
Automobile ownership rates[*6]	671	740	764	783	801	829	849	0.2	0.3	0.3	0.2	0.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A52 United States [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,805	1,915	2,273	2,188	2,254	2,260	2,181	100	100	100	0.6	0.4	0.0	-0.4	0.0
Coal	376	460	534	432	401	334	262	24	20	12	-0.3	-1.0	-1.8	-2.4	-1.8
Oil	797	757	871	780	782	765	702	40	36	32	0.1	0.0	-0.2	-0.9	-0.4
Natural gas	477	438	548	610	668	722	742	23	28	34	1.4	1.3	0.8	0.3	0.7
Nuclear	69	159	208	214	216	217	224	8.3	9.8	10	1.3	0.1	0.0	0.3	0.2
Hydro	24	23	22	23	24	25	25	1.2	1.1	1.2	0.0	0.6	0.2	0.1	0.3
Geothermal	4.6	14	13	8.6	19	24	30	0.7	0.4	1.4	-2.1	12.0	2.2	2.3	4.7
Solar, wind, etc.	-	0.3	2.1	18	28	48	62	0.0	0.8	2.8	19.0	7.2	5.4	2.6	4.8
Biomass and waste	54	62	73	97	109	121	129	3.3	4.4	5.9	2.0	1.6	1.0	0.7	1.1

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,311	1,294	1,546	1,495	1,538	1,557	1,506	100	100	100	0.6	0.4	0.1	-0.3	0.0
Industry	387	284	332	261	267	257	243	22	17	16	-0.4	0.3	-0.4	-0.6	-0.3
Transport	425	488	588	608	618	611	569	38	41	38	1.0	0.2	-0.1	-0.7	-0.2
Buildings, etc.	397	403	473	507	528	548	550	31	34	37	1.0	0.6	0.4	0.0	0.3
Non-energy use	102	119	153	119	125	140	144	9.2	8.0	9.5	0.0	0.7	1.1	0.2	0.7
Coal	56	56	33	22	24	22	19	4.3	1.5	1.2	-3.9	1.3	-1.2	-1.5	-0.7
Oil	689	683	793	731	727	713	656	53	49	44	0.3	-0.1	-0.2	-0.8	-0.4
Natural gas	337	303	360	333	345	345	339	23	22	23	0.4	0.5	0.0	-0.2	0.1
Electricity	174	226	301	325	354	384	396	18	22	26	1.6	1.2	0.8	0.3	0.7
Heat	-	2.2	5.3	5.9	6.4	6.2	6.0	0.2	0.4	0.4	4.5	1.2	-0.3	-0.3	0.1
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	54	23	54	77	81	86	89	1.8	5.2	5.9	5.4	0.7	0.6	0.4	0.5

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,427	3,203	4,026	4,287	4,652	5,037	5,188	100	100	100	1.3	1.2	0.8	0.3	0.7
Coal	1,243	1,700	2,129	1,712	1,617	1,385	1,108	53	40	21	0.0	-0.8	-1.5	-2.2	-1.6
Oil	263	131	118	37	33	24	14	4.1	0.9	0.3	-5.4	-1.8	-2.9	-5.2	-3.5
Natural gas	370	382	634	1,158	1,426	1,776	1,981	12	27	38	4.9	3.0	2.2	1.1	2.0
Nuclear	266	612	798	822	831	832	859	19	19	17	1.3	0.1	0.0	0.3	0.2
Hydro	279	273	253	271	283	290	293	8.5	6.3	5.6	0.0	0.6	0.2	0.1	0.3
Geothermal	5.4	16	15	18	40	50	63	0.5	0.4	1.2	0.6	11.9	2.2	2.4	4.7
Solar, wind, etc.	-	3.7	6.4	190	313	536	695	0.1	4.4	13	18.6	7.4	5.5	2.6	4.9
Biomass and waste	0.5	86	72	78	110	144	175	2.7	1.8	3.4	-0.4	5.0	2.8	1.9	3.0

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	6,514	9,056	12,713	15,902	18,932	23,986	28,725	2.5	2.5	2.4	1.8	2.2
Population (million)	227	250	282	316	332	355	373	1.0	0.7	0.6	0.5	0.6
CO_2 emissions[*2] (Mt)	4,743	4,820	5,617	5,184	5,186	4,954	4,517	0.3	0.0	-0.5	-0.9	-0.5
GDP per capita ($2010 thousand)	29	36	45	50	57	68	77	1.4	1.8	1.7	1.3	1.6
Primary energy consump. per capita (toe)	7.9	7.7	8.1	6.9	6.8	6.4	5.9	-0.4	-0.3	-0.6	-0.8	-0.6
Primary energy consumption per GDP[*3]	277	211	179	138	119	94	76	-1.9	-2.0	-2.3	-2.1	-2.2
CO_2 emissions per GDP[*2, *4]	728	532	442	326	274	207	157	-2.1	-2.5	-2.8	-2.7	-2.7
CO_2 per primary energy consumption[*2, *5]	2.6	2.5	2.5	2.4	2.3	2.2	2.1	-0.3	-0.4	-0.5	-0.6	-0.5
Automobile ownership (million)	156	189	221	253	272	301	323	1.3	1.1	1.0	0.7	0.9
Automobile ownership rates[*6]	686	756	785	799	819	848	867	0.2	0.3	0.3	0.2	0.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A53 Latin America [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	383	464	594	849	964	1,194	1,381	100	100	100	2.7	1.8	2.2	1.5	1.8
Coal	13	20	27	43	45	60	74	4.4	5.0	5.3	3.3	0.6	3.1	2.0	2.0
Oil	223	237	303	390	416	476	506	51	46	37	2.2	0.9	1.4	0.6	1.0
Natural gas	48	72	112	199	235	328	411	16	23	30	4.5	2.4	3.4	2.3	2.7
Nuclear	0.6	3.2	5.3	8.5	12	14	17	0.7	1.0	1.2	4.3	4.4	2.2	1.8	2.6
Hydro	19	33	50	63	69	78	86	7.2	7.4	6.2	2.8	1.4	1.1	1.0	1.2
Geothermal	1.2	5.1	6.3	6.6	19	28	41	1.1	0.8	3.0	1.1	16.7	3.6	4.1	7.0
Solar, wind, etc.	-	0.0	0.2	2.0	4.1	6.7	11	0.0	0.2	0.8	22.8	11.1	4.9	4.7	6.4
Biomass and waste	79	92	89	137	163	203	235	20	16	17	1.7	2.5	2.2	1.5	2.0

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	288	344	449	610	685	841	963	100	100	100	2.5	1.7	2.1	1.4	1.7
Industry	98	115	148	199	220	279	335	33	33	35	2.4	1.5	2.4	1.9	2.0
Transport	85	103	141	216	252	312	346	30	35	36	3.3	2.2	2.2	1.0	1.8
Buildings, etc.	89	101	120	154	169	202	230	29	25	24	1.9	1.3	1.8	1.3	1.5
Non-energy use	16	26	41	40	45	49	52	7.5	6.6	5.4	2.0	1.4	0.9	0.6	0.9
Coal	6.1	8.5	11	17	15	16	16	2.5	2.7	1.7	2.9	-1.6	0.6	0.5	0.0
Oil	159	179	241	307	340	403	436	52	50	45	2.4	1.5	1.7	0.8	1.3
Natural gas	27	38	54	77	88	111	135	11	13	14	3.1	2.0	2.4	1.9	2.1
Electricity	27	44	70	109	127	172	214	13	18	22	4.0	2.2	3.1	2.2	2.5
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	69	74	74	101	115	140	161	22	16	17	1.3	2.0	1.9	1.4	1.8

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	380	623	1,003	1,553	1,787	2,377	2,937	100	100	100	4.0	2.0	2.9	2.1	2.4
Coal	7.8	23	44	99	131	207	275	3.8	6.4	9.3	6.5	4.1	4.7	2.9	3.9
Oil	111	128	194	210	174	164	150	21	14	5.1	2.2	-2.6	-0.6	-0.9	-1.2
Natural gas	35	60	138	398	475	815	1,136	9.6	26	39	8.6	2.6	5.5	3.4	4.0
Nuclear	2.3	12	20	33	44	55	66	2.0	2.1	2.2	4.3	4.4	2.2	1.8	2.6
Hydro	218	386	584	730	806	903	1,002	62	47	34	2.8	1.4	1.1	1.0	1.2
Geothermal	1.4	5.9	7.8	10	23	33	49	1.0	0.6	1.7	2.3	12.6	3.6	4.0	6.0
Solar, wind, etc.	-	0.0	0.3	14	38	61	89	0.0	0.9	3.0	47.1	14.8	5.0	3.8	7.0
Biomass and waste	3.9	7.6	14	59	95	138	172	1.2	3.8	5.8	9.3	7.1	3.9	2.2	4.1

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	2,407	2,764	3,744	5,691	6,515	8,993	11,569	3.2	2.0	3.3	2.6	2.7
Population (million)	360	441	521	611	656	710	749	1.4	1.0	0.8	0.5	0.8
CO_2 emissions[*2] (Mt)	801	905	1,187	1,718	1,881	2,333	2,664	2.8	1.3	2.2	1.3	1.6
GDP per capita ($2010 thousand)	6.7	6.3	7.2	9.3	9.9	13	15	1.7	0.9	2.5	2.0	1.9
Primary energy consump. per capita (toe)	1.1	1.1	1.1	1.4	1.5	1.7	1.8	1.2	0.8	1.4	0.9	1.1
Primary energy consumption per GDP[*3]	159	168	159	149	148	133	119	-0.5	-0.1	-1.1	-1.1	-0.8
CO_2 emissions per GDP[*2, *4]	333	327	317	302	289	259	230	-0.4	-0.6	-1.1	-1.2	-1.0
CO_2 per primary energy consumption[*2, *5]	2.1	2.0	2.0	2.0	2.0	2.0	1.9	0.2	-0.5	0.0	-0.1	-0.2
Automobile ownership (million)	28	38	55	114	141	191	227	4.8	3.1	3.0	1.8	2.6
Automobile ownership rates[*6]	79	87	105	187	215	269	303	3.4	2.1	2.2	1.2	1.8

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A54 OECD Europe [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,494	1,620	1,746	1,737	1,788	1,807	1,795	100	100	100	0.3	0.4	0.1	-0.1	0.1
Coal	464	449	330	307	294	285	265	28	18	15	-1.6	-0.6	-0.3	-0.7	-0.5
Oil	688	606	650	549	519	490	454	37	32	25	-0.4	-0.8	-0.6	-0.8	-0.7
Natural gas	206	260	393	415	454	485	498	16	24	28	2.1	1.3	0.7	0.2	0.7
Nuclear	60	205	245	229	223	204	207	13	13	12	0.5	-0.4	-0.9	0.1	-0.4
Hydro	36	38	47	50	51	52	53	2.4	2.9	2.9	1.1	0.3	0.3	0.1	0.2
Geothermal	3.0	4.9	7.2	13	16	20	23	0.3	0.7	1.3	4.3	3.0	2.1	1.6	2.2
Solar, wind, etc.	0.1	0.3	2.7	32	42	53	62	0.0	1.8	3.4	22.8	4.0	2.4	1.5	2.5
Biomass and waste	36	54	70	141	188	217	233	3.4	8.1	13	4.2	4.2	1.4	0.7	1.9

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,081	1,122	1,225	1,219	1,256	1,268	1,254	100	100	100	0.4	0.4	0.1	-0.1	0.1
Industry	356	323	323	281	294	296	292	29	23	23	-0.6	0.6	0.1	-0.1	0.1
Transport	209	266	316	320	314	299	276	24	26	22	0.8	-0.3	-0.5	-0.8	-0.6
Buildings, etc.	425	433	473	511	529	548	559	39	42	45	0.7	0.5	0.4	0.2	0.3
Non-energy use	90	100	113	106	119	125	128	8.9	8.7	10	0.3	1.6	0.5	0.2	0.7
Coal	156	124	63	49	47	43	38	11	4.0	3.0	-4.0	-0.4	-1.0	-1.1	-0.9
Oil	551	518	568	496	472	447	415	46	41	33	-0.2	-0.7	-0.5	-0.7	-0.7
Natural gas	161	201	268	278	294	308	314	18	23	25	1.4	0.8	0.5	0.2	0.5
Electricity	147	192	233	262	286	308	325	17	22	26	1.4	1.2	0.8	0.5	0.8
Heat	35	40	40	47	48	48	48	3.6	3.8	3.8	0.7	0.3	0.1	-0.1	0.1
Hydrogen	-	-	-	-	0.0	0.5	0.8	-	-	0.1	n.a.	n.a.	62.6	6.2	n.a.
Renewables	31	47	54	87	109	113	114	4.2	7.2	9.1	2.8	3.2	0.3	0.1	1.0

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,049	2,662	3,223	3,559	3,876	4,171	4,388	100	100	100	1.3	1.2	0.7	0.5	0.8
Coal	887	1,030	968	930	907	932	901	39	26	21	-0.4	-0.3	0.3	-0.3	-0.1
Oil	364	206	179	56	40	26	18	7.7	1.6	0.4	-5.5	-4.6	-4.4	-3.8	-4.2
Natural gas	138	168	512	597	738	851	918	6.3	17	21	5.7	3.1	1.4	0.8	1.6
Nuclear	230	787	939	877	854	783	793	30	25	18	0.5	-0.4	-0.9	0.1	-0.4
Hydro	416	446	546	579	592	609	612	17	16	14	1.1	0.3	0.3	0.1	0.2
Geothermal	2.7	3.6	6.2	13	16	21	26	0.1	0.4	0.6	5.6	3.9	2.6	1.9	2.7
Solar, wind, etc.	0.5	1.4	24	325	455	583	683	0.1	9.1	16	26.9	4.9	2.5	1.6	2.8
Biomass and waste	11	21	48	181	272	366	437	0.8	5.1	10.0	9.9	6.0	3.0	1.8	3.3

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	9,906	12,611	15,826	18,688	21,167	24,766	27,948	1.7	1.8	1.6	1.2	1.5
Population (million)	476	499	521	557	570	580	585	0.5	0.3	0.2	0.1	0.2
CO_2 emissions[*2] (Mt)	4,164	3,952	3,891	3,560	3,468	3,398	3,227	-0.5	-0.4	-0.2	-0.5	-0.4
GDP per capita ($2010 thousand)	21	25	30	34	37	43	48	1.2	1.5	1.4	1.1	1.3
Primary energy consump. per capita (toe)	3.1	3.2	3.4	3.1	3.1	3.1	3.1	-0.2	0.1	-0.1	-0.2	-0.1
Primary energy consumption per GDP[*3]	151	128	110	93	84	73	64	-1.4	-1.4	-1.5	-1.3	-1.4
CO_2 emissions per GDP[*2, *4]	420	313	246	190	164	137	115	-2.1	-2.1	-1.8	-1.7	-1.8
CO_2 per primary energy consumption[*2, *5]	2.8	2.4	2.2	2.0	1.9	1.9	1.8	-0.8	-0.8	-0.3	-0.4	-0.5
Automobile ownership (million)	124	179	238	300	327	354	368	2.3	1.3	0.8	0.4	0.8
Automobile ownership rates[*6]	261	360	457	538	574	611	629	1.8	0.9	0.6	0.3	0.6

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A55 Non-OECD Europe [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,241	1,537	1,003	1,156	1,185	1,266	1,323	100	100	100	-1.2	0.4	0.7	0.4	0.5
Coal	362	367	209	219	210	198	192	24	19	15	-2.2	-0.7	-0.6	-0.3	-0.5
Oil	464	468	203	242	248	260	262	30	21	20	-2.8	0.3	0.5	0.1	0.3
Natural gas	355	603	489	569	579	615	641	39	49	48	-0.2	0.2	0.6	0.4	0.4
Nuclear	21	59	64	75	89	124	142	3.9	6.4	11	1.0	2.6	3.4	1.4	2.4
Hydro	20	23	24	27	28	29	30	1.5	2.4	2.3	0.7	0.4	0.3	0.3	0.4
Geothermal	-	0.0	0.1	0.5	1.3	1.7	1.9	0.0	0.0	0.1	14.6	13.7	2.1	1.5	4.8
Solar, wind, etc.	-	-	0.0	1.0	1.8	4.0	7.6	-	0.1	0.6	n.a.	8.8	8.2	6.5	7.7
Biomass and waste	21	17	16	22	28	34	45	1.1	1.9	3.4	1.0	3.6	2.1	2.8	2.8

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	869	1,073	654	704	757	838	896	100	100	100	-1.8	1.0	1.0	0.7	0.9
Industry	394	396	206	203	211	254	287	37	29	32	-2.9	0.6	1.8	1.3	1.3
Transport	107	172	110	144	155	170	178	16	20	20	-0.8	1.0	0.9	0.5	0.8
Buildings, etc.	301	439	288	272	296	314	326	41	39	36	-2.1	1.2	0.6	0.4	0.7
Non-energy use	67	66	49	85	94	101	104	6.2	12	12	1.1	1.5	0.7	0.4	0.8
Coal	152	114	37	40	43	46	48	11	5.7	5.4	-4.4	0.9	0.8	0.4	0.7
Oil	310	280	146	194	199	213	217	26	28	24	-1.6	0.4	0.7	0.2	0.4
Natural gas	215	261	201	209	235	260	280	24	30	31	-1.0	1.7	1.0	0.7	1.1
Electricity	95	126	87	108	115	136	157	12	15	18	-0.7	0.8	1.8	1.4	1.4
Heat	78	279	172	139	149	166	176	26	20	20	-3.0	1.0	1.1	0.6	0.9
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	21	13	12	15	16	17	17	1.2	2.1	1.9	0.6	1.4	0.1	0.0	0.4

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,461	1,894	1,432	1,740	1,827	2,156	2,465	100	100	100	-0.4	0.7	1.7	1.3	1.3
Coal	471	429	338	413	402	396	414	23	24	17	-0.2	-0.4	-0.2	0.4	0.0
Oil	357	256	70	18	17	17	16	14	1.0	0.6	-10.9	-0.5	-0.5	-0.5	-0.5
Natural gas	295	715	504	694	709	863	1,015	38	40	41	-0.1	0.3	2.0	1.6	1.4
Nuclear	79	226	242	284	340	474	543	12	16	22	1.0	2.6	3.4	1.4	2.4
Hydro	232	267	274	316	326	337	348	14	18	14	0.7	0.4	0.3	0.3	0.4
Geothermal	-	0.0	0.1	0.4	1.4	1.7	2.0	0.0	0.0	0.1	12.8	17.3	2.3	1.6	5.7
Solar, wind, etc.	-	-	0.0	11	20	45	86	-	0.6	3.5	n.a.	9.6	8.5	6.7	8.1
Biomass and waste	27	0.0	2.6	4.8	12	23	41	0.0	0.3	1.7	22.1	14.3	6.4	6.2	8.3

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	1,769	2,168	1,509	2,705	2,958	4,019	5,121	1.0	1.3	3.1	2.5	2.4
Population (million)	319	344	341	342	347	347	342	0.0	0.2	0.0	-0.2	0.0
CO_2 emissions[*2] (Mt)	3,497	4,123	2,462	2,720	2,698	2,757	2,794	-1.8	-0.1	0.2	0.1	0.1
GDP per capita ($2010 thousand)	5.5	6.3	4.4	7.9	8.5	12	15	1.0	1.0	3.1	2.6	2.4
Primary energy consump. per capita (toe)	3.9	4.5	2.9	3.4	3.4	3.6	3.9	-1.2	0.1	0.7	0.6	0.5
Primary energy consumption per GDP[*3]	702	709	665	427	400	315	258	-2.2	-0.9	-2.4	-2.0	-1.8
CO_2 emissions per GDP[*2, *4]	1,977	1,902	1,632	1,005	912	686	546	-2.7	-1.4	-2.8	-2.3	-2.2
CO_2 per primary energy consumption[*2, *5]	2.8	2.7	2.5	2.4	2.3	2.2	2.1	-0.6	-0.5	-0.4	-0.3	-0.4
Automobile ownership (million)	22	32	47	92	104	121	132	4.7	1.7	1.5	0.9	1.3
Automobile ownership rates[*6]	69	93	137	270	300	348	385	4.8	1.5	1.5	1.0	1.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A56 European Union [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	n.a.	1,645	1,692	1,626	1,674	1,693	1,682	100	100	100	-0.1	0.4	0.1	-0.1	0.1
Coal	n.a.	456	321	286	273	266	247	28	18	15	-2.0	-0.7	-0.3	-0.8	-0.5
Oil	n.a.	606	623	513	489	463	430	37	32	26	-0.7	-0.7	-0.5	-0.8	-0.7
Natural gas	n.a.	297	396	387	420	449	461	18	24	27	1.2	1.2	0.7	0.2	0.7
Nuclear	n.a.	207	246	229	223	204	205	13	14	12	0.4	-0.4	-0.9	0.1	-0.4
Hydro	n.a.	25	31	32	32	33	33	1.5	2.0	2.0	1.1	0.3	0.2	0.0	0.1
Geothermal	n.a.	3.2	4.6	5.9	7.2	8.2	9.2	0.2	0.4	0.5	2.7	2.9	1.3	1.1	1.6
Solar, wind, etc.	n.a.	0.3	2.4	31	41	53	64	0.0	1.9	3.8	23.2	4.2	2.7	1.8	2.7
Biomass and waste	n.a.	47	66	140	186	213	230	2.8	8.6	14	4.9	4.1	1.4	0.8	1.8

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	n.a.	1,130	1,176	1,139	1,176	1,190	1,179	100	100	100	0.0	0.5	0.1	-0.1	0.1
Industry	n.a.	343	308	258	270	274	273	30	23	23	-1.2	0.7	0.2	-0.1	0.2
Transport	n.a.	259	304	303	300	286	263	23	27	22	0.7	-0.1	-0.5	-0.8	-0.5
Buildings, etc.	n.a.	429	453	478	494	513	523	38	42	44	0.5	0.5	0.4	0.2	0.3
Non-energy use	n.a.	99	111	100	111	117	120	8.7	8.8	10	0.1	1.6	0.5	0.2	0.7
Coal	n.a.	122	52	38	37	34	31	11	3.4	2.6	-4.9	-0.4	-0.9	-1.0	-0.8
Oil	n.a.	503	540	463	444	422	392	45	41	33	-0.4	-0.6	-0.5	-0.7	-0.6
Natural gas	n.a.	226	272	266	280	294	299	20	23	25	0.7	0.8	0.5	0.2	0.4
Electricity	n.a.	186	218	238	259	280	296	16	21	25	1.1	1.2	0.8	0.5	0.8
Heat	n.a.	54	45	48	49	50	50	4.8	4.2	4.2	-0.5	0.4	0.1	0.0	0.1
Hydrogen	n.a.	-	-	-	n.a.	n.a.	n.a.	-	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	n.a.	39	49	85	107	110	111	3.5	7.5	9.4	3.5	3.3	0.3	0.1	1.0

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	n.a.	2,576	3,005	3,230	3,511	3,806	4,041	100	100	100	1.0	1.2	0.8	0.6	0.8
Coal	n.a.	1,050	968	905	883	909	876	41	28	22	-0.6	-0.3	0.3	-0.4	-0.1
Oil	n.a.	224	181	61	46	32	23	8.7	1.9	0.6	-5.5	-4.0	-3.7	-3.0	-3.5
Natural gas	n.a.	193	480	507	617	724	793	7.5	16	20	4.3	2.8	1.6	0.9	1.7
Nuclear	n.a.	795	945	877	854	782	788	31	27	19	0.4	-0.4	-0.9	0.1	-0.4
Hydro	n.a.	290	356	371	378	384	384	11	11	9.5	1.1	0.3	0.2	0.0	0.1
Geothermal	n.a.	3.2	4.8	5.9	7.4	8.4	9.3	0.1	0.2	0.2	2.7	3.1	1.3	1.1	1.7
Solar, wind, etc.	n.a.	1.3	24	324	457	602	728	0.1	10	18	27.1	5.0	2.8	1.9	3.0
Biomass and waste	n.a.	20	46	178	269	363	439	0.8	5.5	11	10.1	6.1	3.1	1.9	3.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	n.a.	11,862	14,721	17,159	19,411	22,767	25,759	1.6	1.8	1.6	1.2	1.5
Population (million)	n.a.	478	488	507	516	523	526	0.3	0.3	0.1	0.0	0.1
CO_2 emissions[*2] (Mt)	n.a.	4,068	3,783	3,320	3,239	3,184	3,023	-0.9	-0.4	-0.2	-0.5	-0.3
GDP per capita ($2010 thousand)	n.a.	25	30	34	38	44	49	1.4	1.5	1.5	1.2	1.4
Primary energy consump. per capita (toe)	n.a.	3.4	3.5	3.2	3.2	3.2	3.2	-0.3	0.2	0.0	-0.1	0.0
Primary energy consumption per GDP[*3]	n.a.	139	115	95	86	74	65	-1.6	-1.3	-1.5	-1.3	-1.4
CO_2 emissions per GDP[*2, *4]	n.a.	343	257	193	167	140	117	-2.5	-2.1	-1.8	-1.7	-1.8
CO_2 per primary energy consumption[*2, *5]	n.a.	2.5	2.2	2.0	1.9	1.9	1.8	-0.8	-0.8	-0.3	-0.5	-0.5
Automobile ownership (million)	n.a.	177	235	294	319	345	358	2.2	1.2	0.8	0.4	0.7
Automobile ownership rates[*6]	n.a.	371	482	580	619	660	681	2.0	0.9	0.6	0.3	0.6

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A57 Africa [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	272	391	494	747	906	1,134	1,368	100	100	100	2.9	2.8	2.3	1.9	2.3
Coal	52	74	90	104	126	144	167	19	14	12	1.5	2.7	1.4	1.5	1.8
Oil	61	86	98	168	207	248	284	22	23	21	2.9	3.0	1.8	1.4	2.0
Natural gas	12	30	47	100	133	192	260	7.6	13	19	5.4	4.1	3.8	3.1	3.6
Nuclear	-	2.2	3.4	3.7	3.7	7.9	8.2	0.6	0.5	0.6	2.3	0.1	7.9	0.3	3.0
Hydro	4.1	4.8	6.4	10	11	12	13	1.2	1.3	0.9	3.2	0.9	0.9	0.8	0.8
Geothermal	-	0.3	0.4	1.7	5.1	7.4	8.3	0.1	0.2	0.6	8.3	16.6	3.8	1.1	6.0
Solar, wind, etc.	-	0.0	0.0	0.5	1.4	2.5	5.0	0.0	0.1	0.4	34.9	16.6	5.6	7.3	9.0
Biomass and waste	142	194	248	358	419	520	622	50	48	45	2.7	2.3	2.2	1.8	2.1

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	218	292	370	555	673	846	1,028	100	100	100	2.8	2.8	2.3	2.0	2.3
Industry	46	55	58	85	107	142	183	19	15	18	1.9	3.4	2.9	2.5	2.9
Transport	27	38	54	97	121	145	164	13	17	16	4.2	3.3	1.8	1.2	2.0
Buildings, etc.	139	188	243	354	421	530	647	64	64	63	2.8	2.5	2.3	2.0	2.3
Non-energy use	5.4	11	15	19	24	29	35	3.8	3.5	3.4	2.4	3.0	2.0	1.8	2.2
Coal	22	20	19	22	28	35	42	6.7	3.9	4.1	0.4	3.5	2.3	2.0	2.5
Oil	54	71	89	148	186	227	264	24	27	26	3.3	3.4	2.0	1.5	2.2
Natural gas	2.8	8.6	14	32	38	51	66	2.9	5.8	6.4	5.9	2.5	2.9	2.7	2.7
Electricity	14	22	31	51	66	91	121	7.6	9.2	12	3.7	3.7	3.2	2.9	3.2
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	126	171	217	302	355	442	535	59	54	52	2.5	2.3	2.2	1.9	2.1

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	184	316	442	732	933	1,271	1,678	100	100	100	3.7	3.5	3.1	2.8	3.1
Coal	100	165	209	258	315	379	466	52	35	28	2.0	2.9	1.9	2.1	2.2
Oil	22	41	51	73	75	77	79	13	10.0	4.7	2.6	0.4	0.2	0.2	0.3
Natural gas	14	45	92	263	382	611	886	14	36	53	8.0	5.5	4.8	3.8	4.6
Nuclear	-	8.4	13	14	14	30	31	2.7	1.9	1.9	2.3	0.1	7.9	0.3	3.0
Hydro	47	56	75	116	124	135	146	18	16	8.7	3.2	0.9	0.9	0.8	0.8
Geothermal	-	0.3	0.4	2.0	5.9	8.7	9.7	0.1	0.3	0.6	8.3	16.6	3.8	1.1	6.0
Solar, wind, etc.	-	-	0.2	4.2	15	27	57	-	0.6	3.4	n.a.	20.7	5.8	7.6	10.2
Biomass and waste	0.2	0.5	1.1	1.3	2.0	2.6	3.5	0.1	0.2	0.2	4.5	6.9	2.7	2.8	3.8

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	730	886	1,145	2,117	2,924	4,566	6,928	3.9	4.7	4.6	4.3	4.5
Population (million)	476	627	806	1,109	1,318	1,652	2,030	2.5	2.5	2.3	2.1	2.3
CO_2 emissions[*2] (Mt)	403	593	718	1,108	1,377	1,702	2,050	2.8	3.2	2.1	1.9	2.3
GDP per capita ($2010 thousand)	1.5	1.4	1.4	1.9	2.2	2.8	3.4	1.3	2.2	2.2	2.1	2.2
Primary energy consump. per capita (toe)	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.3	0.3	0.0	-0.2	0.0
Primary energy consumption per GDP[*3]	372	441	432	353	310	248	198	-1.0	-1.8	-2.2	-2.3	-2.1
CO_2 emissions per GDP[*2, *4]	552	669	627	523	471	373	296	-1.1	-1.5	-2.3	-2.3	-2.1
CO_2 per primary energy consumption[*2, *5]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	-0.1	0.3	-0.1	0.0	0.0
Automobile ownership (million)	9.8	14	20	35	49	70	95	4.0	4.7	3.7	3.1	3.7
Automobile ownership rates[*6]	21	23	24	32	37	42	47	1.4	2.1	1.4	1.0	1.4

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A58 Middle East [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	121	222	374	713	837	1,006	1,160	100	100	100	5.2	2.3	1.9	1.4	1.8
Coal	1.2	3.0	8.1	10	12	16	21	1.3	1.4	1.8	5.4	2.9	2.8	2.6	2.7
Oil	90	146	217	342	393	455	509	66	48	44	3.8	2.0	1.5	1.1	1.5
Natural gas	29	72	148	356	422	510	593	32	50	51	7.2	2.5	1.9	1.5	1.9
Nuclear	-	-	-	1.4	4.4	19	29	-	0.2	2.5	n.a.	17.6	15.9	4.4	11.9
Hydro	0.8	1.0	0.7	2.2	2.0	2.0	2.0	0.5	0.3	0.2	3.3	-1.0	0.0	0.0	-0.2
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.4	0.7	1.3	2.2	3.4	5.0	0.2	0.2	0.4	5.2	7.2	4.7	4.0	5.0
Biomass and waste	0.3	0.4	0.4	0.9	1.0	1.1	1.2	0.2	0.1	0.1	3.1	1.3	0.9	0.8	0.9

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	84	157	255	467	558	685	801	100	100	100	4.9	2.6	2.1	1.6	2.0
Industry	30	47	73	150	180	231	277	30	32	35	5.2	2.6	2.5	1.8	2.3
Transport	26	50	74	135	155	189	216	32	29	27	4.4	2.1	1.9	1.4	1.8
Buildings, etc.	22	40	76	122	144	175	207	26	26	26	4.9	2.4	1.9	1.7	2.0
Non-energy use	5.6	20	32	60	78	91	101	12	13	13	5.0	3.9	1.6	1.0	2.0
Coal	0.3	0.2	0.5	2.2	3.0	4.2	5.2	0.1	0.5	0.7	11.3	4.7	3.3	2.2	3.3
Oil	67	108	154	229	265	318	365	69	49	45	3.3	2.1	1.8	1.4	1.7
Natural gas	9.8	31	68	162	196	239	274	20	35	34	7.4	2.8	2.0	1.4	2.0
Electricity	6.5	17	33	72	90	121	153	11	15	19	6.4	3.3	2.9	2.4	2.8
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	0.2	0.7	1.0	2.1	2.6	3.4	4.3	0.5	0.4	0.5	4.5	3.3	2.7	2.5	2.8

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	95	244	472	1,012	1,262	1,671	2,115	100	100	100	6.4	3.2	2.8	2.4	2.8
Coal	0.1	11	30	33	40	52	70	4.3	3.2	3.3	5.0	2.8	2.9	2.9	2.9
Oil	47	108	188	318	380	464	541	44	31	26	4.8	2.6	2.0	1.5	2.0
Natural gas	39	114	246	630	796	1,046	1,348	47	62	64	7.7	3.4	2.8	2.6	2.9
Nuclear	-	-	-	5.4	17	74	113	-	0.5	5.3	n.a.	17.6	15.9	4.4	11.9
Hydro	9.7	12	8.0	25	24	24	24	4.9	2.5	1.1	3.3	-1.0	0.0	0.0	-0.2
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	0.0	0.7	5.0	11	19	0.0	0.1	0.9	33.0	32.1	8.3	5.8	13.1
Biomass and waste	-	-	-	0.1	0.2	0.3	0.4	-	0.0	0.0	n.a.	9.4	4.8	2.8	5.2

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	821	902	1,393	2,419	2,984	4,054	5,153	4.4	3.0	3.1	2.4	2.8
Population (million)	92	132	166	226	256	296	332	2.4	1.8	1.5	1.1	1.4
CO_2 emissions[*2] (Mt)	332	571	952	1,756	2,028	2,402	2,754	5.0	2.1	1.7	1.4	1.7
GDP per capita ($2010 thousand)	8.9	6.9	8.4	11	12	14	16	2.0	1.2	1.6	1.3	1.4
Primary energy consump. per capita (toe)	1.3	1.7	2.2	3.2	3.3	3.4	3.5	2.8	0.5	0.4	0.3	0.4
Primary energy consumption per GDP[*3]	148	246	269	295	280	248	225	0.8	-0.7	-1.2	-1.0	-1.0
CO_2 emissions per GDP[*2, *4]	405	634	683	726	680	593	534	0.6	-0.9	-1.4	-1.0	-1.1
CO_2 per primary energy consumption[*2, *5]	2.7	2.6	2.5	2.5	2.4	2.4	2.4	-0.2	-0.2	-0.2	-0.1	-0.1
Automobile ownership (million)	5.8	10	14	37	45	62	77	5.8	2.9	3.1	2.2	2.7
Automobile ownership rates[*6]	63	78	85	164	177	208	232	3.3	1.1	1.6	1.1	1.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A59 Oceania [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
Total[*1]	79	99	125	149	162	169	172	100	100	100	1.8	1.2	0.4	0.2	0.5
Coal	28	36	49	47	48	47	45	37	32	26	1.1	0.3	-0.2	-0.6	-0.2
Oil	34	35	40	52	57	61	63	35	35	37	1.8	1.3	0.7	0.3	0.7
Natural gas	8.3	19	24	34	36	36	37	19	23	21	2.6	0.8	0.2	0.1	0.3
Nuclear	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydro	2.7	3.2	3.5	3.5	3.6	4.1	4.4	3.2	2.4	2.6	0.4	0.3	1.2	0.9	0.8
Geothermal	1.0	1.5	1.9	4.2	7.3	7.6	8.0	1.5	2.9	4.6	4.7	8.0	0.4	0.5	2.4
Solar, wind, etc.	0.0	0.1	0.1	1.5	2.8	4.8	7.2	0.1	1.0	4.2	11.3	9.8	5.4	4.2	6.1
Biomass and waste	4.1	4.7	6.1	6.2	7.0	7.6	8.1	4.8	4.2	4.7	1.2	1.8	0.9	0.6	1.0

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
Total	54	66	83	94	105	114	120	100	100	100	1.5	1.6	0.8	0.5	0.9
Industry	20	23	28	29	33	35	36	35	31	30	1.1	1.5	0.6	0.3	0.7
Transport	19	24	30	36	39	42	44	36	38	36	1.7	1.2	0.7	0.4	0.7
Buildings, etc.	11	15	19	23	26	29	32	22	25	27	1.9	1.8	1.2	0.9	1.2
Non-energy use	3.1	4.6	6.1	5.9	7.4	8.1	8.4	6.9	6.3	7.0	1.1	3.2	1.0	0.4	1.3
Coal	5.3	5.2	4.7	3.9	4.9	5.5	5.9	7.9	4.2	4.9	-1.2	3.3	1.1	0.7	1.5
Oil	31	33	40	47	52	57	59	50	50	49	1.6	1.4	0.8	0.4	0.8
Natural gas	5.4	10	14	16	17	18	18	16	17	15	1.8	1.3	0.5	0.2	0.6
Electricity	8.5	14	18	21	24	27	29	20	22	24	1.9	1.7	1.2	1.0	1.2
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	4.0	4.1	5.6	6.1	6.8	7.2	7.4	6.2	6.5	6.2	1.7	1.5	0.7	0.3	0.8

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
Total	118	187	249	292	329	370	408	100	100	100	2.0	1.7	1.2	1.0	1.2
Coal	70	122	176	164	173	179	177	65	56	44	1.3	0.8	0.4	-0.1	0.3
Oil	5.2	3.6	1.8	3.4	2.8	2.6	1.8	1.9	1.2	0.4	-0.2	-2.7	-1.0	-3.6	-2.4
Natural gas	8.7	20	26	62	68	75	80	11	21	20	5.0	1.4	0.9	0.8	1.0
Nuclear	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydro	32	37	41	41	42	47	52	20	14	13	0.4	0.3	1.2	0.9	0.8
Geothermal	1.2	2.1	2.9	6.4	11	12	12	1.1	2.2	3.0	4.9	8.4	0.3	0.5	2.4
Solar, wind, etc.	-	0.1	0.3	13	28	51	79	0.0	4.5	19	25.8	11.6	6.0	4.5	6.9
Biomass and waste	0.7	1.3	1.7	2.6	3.2	4.0	4.9	0.7	0.9	1.2	3.2	3.1	2.2	2.1	2.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/2013	2013/2020	2020/2030	2030/2040	2013/2040
GDP ($2010 billion)	524	719	993	1,447	1,769	2,206	2,598	3.1	2.9	2.2	1.7	2.2
Population (million)	18	20	23	28	30	33	36	1.3	1.3	1.0	0.8	1.0
CO_2 emissions[*2] (Mt)	227	281	357	410	428	437	433	1.7	0.6	0.2	-0.1	0.2
GDP per capita ($2010 thousand)	29	35	43	52	59	66	72	1.7	1.6	1.2	0.8	1.2
Primary energy consump. per capita (toe)	4.4	4.9	5.4	5.4	5.4	5.1	4.8	0.4	-0.1	-0.6	-0.6	-0.5
Primary energy consumption per GDP[*3]	150	138	126	103	91	77	66	-1.3	-1.7	-1.7	-1.4	-1.6
CO_2 emissions per GDP[*2, *4]	433	390	360	283	242	198	167	-1.4	-2.2	-2.0	-1.7	-1.9
CO_2 per primary energy consumption[*2, *5]	2.9	2.8	2.9	2.8	2.7	2.6	2.5	-0.1	-0.5	-0.2	-0.3	-0.3
Automobile ownership (million)	8.8	12	15	20	22	25	27	2.3	1.8	1.2	0.8	1.2
Automobile ownership rates[*6]	495	567	644	711	737	754	755	1.0	0.5	0.2	0.0	0.2

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million, *4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A60 OECD [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	4,060	4,511	5,274	5,276	5,520	5,627	5,558	100	100	100	0.7	0.6	0.2	-0.1	0.2
Coal	966	1,078	1,094	1,022	978	916	818	24	19	15	-0.2	-0.6	-0.6	-1.1	-0.8
Oil	1,938	1,861	2,103	1,874	1,848	1,803	1,692	41	36	30	0.0	-0.2	-0.2	-0.6	-0.4
Natural gas	778	843	1,156	1,365	1,477	1,612	1,662	19	26	30	2.1	1.1	0.9	0.3	0.7
Nuclear	162	451	586	511	589	560	563	10	9.7	10	0.5	2.0	-0.5	0.1	0.4
Hydro	94	102	115	122	127	132	135	2.3	2.3	2.4	0.8	0.6	0.4	0.2	0.4
Geothermal	10	27	30	32	59	77	99	0.6	0.6	1.8	0.8	9.2	2.7	2.6	4.3
Solar, wind, etc.	0.1	1.9	5.8	55	81	118	149	0.0	1.0	2.7	15.7	5.7	3.9	2.4	3.8
Biomass and waste	111	147	182	293	359	406	436	3.3	5.6	7.9	3.0	2.9	1.2	0.7	1.5

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,937	3,099	3,631	3,631	3,783	3,867	3,819	100	100	100	0.7	0.6	0.2	-0.1	0.2
Industry	940	826	908	794	839	851	843	27	22	22	-0.2	0.8	0.1	-0.1	0.2
Transport	781	938	1,143	1,189	1,215	1,202	1,133	30	33	30	1.0	0.3	-0.1	-0.6	-0.2
Buildings, etc.	972	1,044	1,209	1,305	1,358	1,415	1,434	34	36	38	1.0	0.6	0.4	0.1	0.4
Non-energy use	243	290	370	343	371	400	409	9.3	9.5	11	0.7	1.1	0.7	0.2	0.7
Coal	259	234	140	119	122	113	101	7.6	3.3	2.6	-2.9	0.4	-0.8	-1.2	-0.6
Oil	1,570	1,586	1,840	1,705	1,700	1,669	1,571	51	47	41	0.3	0.0	-0.2	-0.6	-0.3
Natural gas	559	589	746	745	783	808	811	19	21	21	1.0	0.7	0.3	0.0	0.3
Electricity	408	550	714	800	882	968	1,018	18	22	27	1.6	1.4	0.9	0.5	0.9
Heat	36	43	50	58	61	64	65	1.4	1.6	1.7	1.3	0.8	0.3	0.2	0.4
Hydrogen	-	-	-	-	0.0	0.7	1.3	-	-	0.0	n.a.	n.a.	36.4	6.6	n.a.
Renewables	105	97	140	203	233	244	252	3.1	5.6	6.6	3.3	2.0	0.5	0.3	0.8

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	5,656	7,608	9,685	10,736	11,789	12,883	13,513	100	100	100	1.5	1.3	0.9	0.5	0.9
Coal	2,319	3,082	3,759	3,493	3,390	3,281	3,004	41	33	22	0.5	-0.4	-0.3	-0.9	-0.6
Oil	980	676	580	328	191	141	108	8.9	3.1	0.8	-3.1	-7.4	-3.0	-2.6	-4.0
Natural gas	618	782	1,543	2,608	3,054	3,769	4,178	10	24	31	5.4	2.3	2.1	1.0	1.8
Nuclear	621	1,729	2,249	1,962	2,259	2,149	2,162	23	18	16	0.5	2.0	-0.5	0.1	0.4
Hydro	1,093	1,182	1,341	1,413	1,476	1,535	1,569	16	13	12	0.8	0.6	0.4	0.2	0.4
Geothermal	11	29	33	46	87	113	146	0.4	0.4	1.1	2.1	9.5	2.6	2.6	4.4
Solar, wind, etc.	0.5	5.2	32	568	877	1,298	1,636	0.1	5.3	12	22.7	6.4	4.0	2.3	4.0
Biomass and waste	13	124	148	317	454	595	710	1.6	2.9	5.3	4.2	5.3	2.8	1.8	3.0

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	21,337	29,024	37,701	46,008	53,678	65,412	76,233	2.0	2.2	2.0	1.5	1.9
Population (million)	982	1,062	1,150	1,254	1,299	1,348	1,380	0.7	0.5	0.4	0.2	0.4
CO_2 emissions[*2] (Mt)	10,863	11,096	12,396	11,975	11,898	11,753	11,118	0.3	-0.1	-0.1	-0.6	-0.3
GDP per capita ($2010 thousand)	22	27	33	37	41	49	55	1.3	1.7	1.6	1.3	1.5
Primary energy consump. per capita (toe)	4.1	4.2	4.6	4.2	4.2	4.2	4.0	0.0	0.1	-0.2	-0.4	-0.2
Primary energy consumption per GDP[*3]	190	155	140	115	103	86	73	-1.3	-1.5	-1.8	-1.6	-1.7
CO_2 emissions per GDP[*2, *4]	509	382	329	260	222	180	146	-1.7	-2.3	-2.1	-2.1	-2.1
CO_2 per primary energy consumption[*2, *5]	2.7	2.5	2.4	2.3	2.2	2.1	2.0	-0.3	-0.7	-0.3	-0.4	-0.5
Automobile ownership (million)	347	468	593	729	795	871	922	1.9	1.3	0.9	0.6	0.9
Automobile ownership rates[*6]	353	441	516	581	612	646	668	1.2	0.7	0.5	0.3	0.5

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A61 Non-OECD [Reference Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	2,966	4,055	4,509	7,925	9,251	11,055	12,796	100	100	100	3.0	2.2	1.8	1.5	1.8
Coal	818	1,143	1,248	2,905	3,165	3,451	3,759	28	37	29	4.1	1.2	0.9	0.9	1.0
Oil	986	1,169	1,283	1,982	2,340	2,811	3,230	29	25	25	2.3	2.4	1.9	1.4	1.8
Natural gas	454	820	911	1,536	1,873	2,462	3,044	20	19	24	2.8	2.9	2.8	2.1	2.6
Nuclear	24	74	89	135	255	421	563	1.8	1.7	4.4	2.6	9.5	5.1	3.0	5.4
Hydro	54	83	110	204	242	270	299	2.0	2.6	2.3	4.0	2.5	1.1	1.0	1.4
Geothermal	2.2	7.6	22	35	87	113	129	0.2	0.4	1.0	6.8	14.2	2.6	1.3	5.0
Solar, wind, etc.	-	0.5	2.1	40	64	102	152	0.0	0.5	1.2	21.3	6.8	4.8	4.0	5.0
Biomass and waste	630	758	843	1,084	1,221	1,420	1,612	19	14	13	1.6	1.7	1.5	1.3	1.5

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,259	2,980	3,180	5,188	6,091	7,339	8,564	100	100	100	2.4	2.3	1.9	1.6	1.9
Industry	832	981	987	1,830	2,091	2,460	2,835	33	35	33	2.7	1.9	1.6	1.4	1.6
Transport	289	435	549	1,009	1,233	1,560	1,847	15	19	22	3.7	2.9	2.4	1.7	2.3
Buildings, etc.	1,028	1,377	1,396	1,894	2,211	2,655	3,119	46	37	36	1.4	2.2	1.8	1.6	1.9
Non-energy use	111	187	249	456	556	664	763	6.3	8.8	8.9	3.9	2.9	1.8	1.4	1.9
Coal	451	532	438	835	885	887	893	18	16	10	2.0	0.8	0.0	0.1	0.2
Oil	697	819	1,013	1,644	1,986	2,439	2,847	27	32	33	3.1	2.7	2.1	1.6	2.1
Natural gas	256	355	375	655	821	1,073	1,328	12	13	16	2.7	3.3	2.7	2.2	2.7
Electricity	178	283	377	876	1,105	1,478	1,873	9.5	17	22	5.0	3.4	2.9	2.4	2.9
Heat	85	293	198	216	238	261	274	9.8	4.2	3.2	-1.3	1.4	1.0	0.5	0.9
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	593	699	779	961	1,056	1,200	1,349	23	19	16	1.4	1.4	1.3	1.2	1.3

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,628	4,218	5,741	12,571	15,625	20,663	25,996	100	100	100	4.9	3.2	2.8	2.3	2.7
Coal	817	1,342	2,243	6,120	7,037	8,798	10,684	32	49	41	6.8	2.0	2.3	2.0	2.1
Oil	678	636	625	700	757	850	924	15	5.6	3.6	0.4	1.1	1.2	0.8	1.0
Natural gas	381	979	1,210	2,467	3,284	5,046	7,027	23	20	27	4.1	4.2	4.4	3.4	4.0
Nuclear	93	283	341	516	977	1,612	2,159	6.7	4.1	8.3	2.6	9.5	5.1	3.0	5.4
Hydro	624	963	1,279	2,377	2,817	3,144	3,478	23	19	13	4.0	2.5	1.1	1.0	1.4
Geothermal	2.6	7.8	19	26	63	81	93	0.2	0.2	0.4	5.3	13.7	2.5	1.4	4.9
Solar, wind, etc.	-	0.0	3.1	221	449	759	1,143	0.0	1.8	4.4	44.8	10.7	5.4	4.2	6.3
Biomass and waste	31	7.7	21	145	240	372	488	0.2	1.2	1.9	13.6	7.5	4.5	2.7	4.6

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	6,444	8,490	11,654	24,534	33,461	52,623	76,047	4.7	4.5	4.6	3.8	4.3
Population (million)	3,453	4,209	4,943	5,860	6,386	7,071	7,688	1.4	1.2	1.0	0.8	1.0
CO_2 emissions[*2] (Mt)	7,000	9,484	10,284	19,859	22,489	26,137	29,732	3.3	1.8	1.5	1.3	1.5
GDP per capita ($2010 thousand)	1.9	2.0	2.4	4.2	5.2	7.4	9.9	3.2	3.3	3.6	2.9	3.2
Primary energy consump. per capita (toe)	0.9	1.0	0.9	1.4	1.4	1.6	1.7	1.5	1.0	0.8	0.6	0.8
Primary energy consumption per GDP[*3]	460	478	387	323	276	210	168	-1.7	-2.2	-2.7	-2.2	-2.4
CO_2 emissions per GDP[*2, *4]	1,086	1,117	882	809	672	497	391	-1.4	-2.6	-3.0	-2.4	-2.7
CO_2 per primary energy consumption[*2, *5]	2.4	2.3	2.3	2.5	2.4	2.4	2.3	0.3	-0.4	-0.3	-0.2	-0.3
Automobile ownership (million)	69	109	173	467	654	931	1,220	6.5	4.9	3.6	2.7	3.6
Automobile ownership rates[*6]	20	26	35	80	102	132	159	5.0	3.7	2.5	1.9	2.6

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A62 World [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	7,205	8,768	10,057	13,555	14,615	15,702	16,396	100	100	100	1.9	1.1	0.7	0.4	0.7
Coal	1,783	2,221	2,343	3,928	3,854	3,503	3,105	25	29	19	2.5	-0.3	-0.9	-1.2	-0.9
Oil	3,102	3,232	3,660	4,210	4,402	4,583	4,658	37	31	28	1.2	0.6	0.4	0.2	0.4
Natural gas	1,232	1,663	2,067	2,902	3,166	3,484	3,665	19	21	22	2.4	1.3	1.0	0.5	0.9
Nuclear	186	526	676	646	883	1,270	1,597	6.0	4.8	9.7	0.9	4.6	3.7	2.3	3.4
Hydro	148	184	225	326	375	410	443	2.1	2.4	2.7	2.5	2.0	0.9	0.8	1.1
Geothermal	12	34	52	66	158	293	395	0.4	0.5	2.4	2.9	13.3	6.3	3.0	6.8
Solar, wind, etc.	0.1	2.4	7.9	95	176	305	462	0.0	0.7	2.8	17.3	9.2	5.6	4.2	6.0
Biomass and waste	741	905	1,025	1,377	1,593	1,846	2,061	10	10	13	1.8	2.1	1.5	1.1	1.5

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	5,375	6,281	7,085	9,173	9,942	10,740	11,313	100	100	100	1.7	1.2	0.8	0.5	0.8
Industry	1,773	1,807	1,895	2,623	2,829	3,030	3,201	29	29	28	1.6	1.1	0.7	0.6	0.7
Transport	1,248	1,576	1,965	2,552	2,795	3,037	3,171	25	28	28	2.1	1.3	0.8	0.4	0.8
Buildings, etc.	2,000	2,421	2,605	3,199	3,391	3,609	3,771	39	35	33	1.2	0.8	0.6	0.4	0.6
Non-energy use	354	477	619	799	927	1,064	1,171	7.6	8.7	10	2.3	2.1	1.4	1.0	1.4
Coal	709	766	578	954	977	908	839	12	10	7.4	1.0	0.3	-0.7	-0.8	-0.5
Oil	2,446	2,606	3,127	3,704	3,924	4,129	4,225	41	40	37	1.5	0.8	0.5	0.2	0.5
Natural gas	814	944	1,121	1,400	1,586	1,769	1,915	15	15	17	1.7	1.8	1.1	0.8	1.2
Electricity	586	834	1,091	1,677	1,902	2,207	2,450	13	18	22	3.1	1.8	1.5	1.1	1.4
Heat	121	335	247	274	284	288	279	5.3	3.0	2.5	-0.9	0.5	0.1	-0.3	0.1
Hydrogen	-	-	-	-	0.1	7.3	15	-	-	0.1	n.a.	n.a.	51.3	7.3	n.a.
Renewables	698	796	920	1,164	1,269	1,432	1,590	13	13	14	1.7	1.2	1.2	1.1	1.2

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	8,283	11,826	15,426	23,307	26,292	30,411	33,671	100	100	100	3.0	1.7	1.5	1.0	1.4
Coal	3,137	4,424	6,002	9,613	9,442	9,011	8,205	37	41	24	3.4	-0.3	-0.5	-0.9	-0.6
Oil	1,659	1,311	1,205	1,028	871	830	814	11	4.4	2.4	-1.1	-2.3	-0.5	-0.2	-0.9
Natural gas	999	1,760	2,752	5,075	5,573	6,484	6,999	15	22	21	4.7	1.3	1.5	0.8	1.2
Nuclear	713	2,013	2,591	2,478	3,386	4,870	6,127	17	11	18	0.9	4.6	3.7	2.3	3.4
Hydro	1,717	2,145	2,620	3,790	4,355	4,769	5,150	18	16	15	2.5	2.0	0.9	0.8	1.1
Geothermal	14	36	52	72	164	311	419	0.3	0.3	1.2	3.0	12.6	6.6	3.0	6.8
Solar, wind, etc.	0.5	5.2	35	789	1,697	3,059	4,685	0.0	3.4	14	24.4	11.6	6.1	4.4	6.8
Biomass and waste	44	132	170	461	802	1,074	1,272	1.1	2.0	3.8	5.6	8.2	3.0	1.7	3.8

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	27,780	37,514	49,355	70,542	87,153	118,071	152,341	2.8	3.1	3.1	2.6	2.9
Population (million)	4,435	5,271	6,093	7,114	7,685	8,420	9,068	1.3	1.1	0.9	0.7	0.9
CO_2 emissions[*2] (Mt)	18,411	21,200	23,520	32,920	33,470	32,986	31,762	1.9	0.2	-0.1	-0.4	-0.1
GDP per capita ($2010 thousand)	6.3	7.1	8.1	9.9	11	14	17	1.5	1.9	2.1	1.8	2.0
Primary energy consump. per capita (toe)	1.6	1.7	1.7	1.9	1.9	1.9	1.8	0.6	0.0	-0.2	-0.3	-0.2
Primary energy consumption per GDP[*3]	259	234	204	192	168	133	108	-0.8	-1.9	-2.3	-2.1	-2.1
CO_2 emissions per GDP[*2, *4]	663	565	477	467	384	279	208	-0.8	-2.7	-3.1	-2.9	-2.9
CO_2 per primary energy consumption[*2, *5]	2.6	2.4	2.3	2.4	2.3	2.1	1.9	0.0	-0.8	-0.9	-0.8	-0.8
Automobile ownership (million)	416	577	767	1,195	1,449	1,800	2,138	3.2	2.8	2.2	1.7	2.2
Automobile ownership rates[*6]	94	109	126	168	189	214	236	1.9	1.7	1.3	1.0	1.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A63 Asia [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,440	2,110	2,920	5,409	6,213	6,961	7,534	100	100	100	4.2	2.0	1.1	0.8	1.2
Coal	466	786	1,063	2,747	2,832	2,692	2,460	37	51	33	5.6	0.4	-0.5	-0.9	-0.4
Oil	477	618	917	1,254	1,434	1,623	1,778	29	23	24	3.1	1.9	1.3	0.9	1.3
Natural gas	51	116	232	532	684	943	1,149	5.5	9.8	15	6.9	3.7	3.3	2.0	2.9
Nuclear	25	77	132	89	292	520	760	3.6	1.6	10	0.6	18.6	5.9	3.9	8.3
Hydro	20	32	41	113	152	173	195	1.5	2.1	2.6	5.7	4.2	1.3	1.2	2.0
Geothermal	2.6	8.2	23	31	83	148	199	0.4	0.6	2.6	6.0	14.8	6.0	3.0	7.1
Solar, wind, etc.	-	1.2	2.1	38	74	135	206	0.1	0.7	2.7	16.1	9.8	6.2	4.3	6.4
Biomass and waste	397	472	510	602	659	721	781	22	11	10	1.1	1.3	0.9	0.8	1.0

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,136	1,572	2,039	3,476	3,979	4,490	4,940	100	100	100	3.5	1.9	1.2	1.0	1.3
Industry	390	518	672	1,367	1,524	1,622	1,715	33	39	35	4.3	1.6	0.6	0.6	0.8
Transport	126	190	325	581	701	853	987	12	17	20	5.0	2.7	2.0	1.5	2.0
Buildings, etc.	567	748	852	1,188	1,346	1,526	1,676	48	34	34	2.0	1.8	1.3	0.9	1.3
Non-energy use	54	116	190	340	408	489	564	7.4	9.8	11	4.8	2.6	1.8	1.4	1.9
Coal	308	435	408	795	817	755	693	28	23	14	2.7	0.4	-0.8	-0.9	-0.5
Oil	327	464	742	1,102	1,301	1,491	1,646	30	32	33	3.8	2.4	1.4	1.0	1.5
Natural gas	21	47	89	248	329	464	599	3.0	7.1	12	7.5	4.1	3.5	2.6	3.3
Electricity	88	156	278	686	855	1,065	1,236	9.9	20	25	6.7	3.2	2.2	1.5	2.2
Heat	7.5	14	30	82	93	97	96	0.9	2.4	1.9	7.9	1.8	0.4	-0.1	0.6
Hydrogen	-	-	-	-	0.1	0.8	2.7	-	-	0.1	n.a.	n.a.	28.5	13.1	n.a.
Renewables	386	456	493	562	584	619	668	29	16	14	0.9	0.6	0.6	0.8	0.6

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,196	2,215	3,974	9,481	11,701	14,446	16,649	100	100	100	6.5	3.1	2.1	1.4	2.1
Coal	298	862	1,990	5,939	6,292	6,582	6,385	39	63	38	8.8	0.8	0.5	-0.3	0.3
Oil	476	422	386	306	199	176	156	19	3.2	0.9	-1.4	-6.0	-1.2	-1.2	-2.5
Natural gas	90	247	567	1,206	1,444	2,072	2,571	11	13	15	7.1	2.6	3.7	2.2	2.8
Nuclear	97	294	505	340	1,122	1,995	2,916	13	3.6	18	0.6	18.6	5.9	3.9	8.3
Hydro	232	370	481	1,319	1,763	2,014	2,266	17	14	14	5.7	4.2	1.3	1.2	2.0
Geothermal	3.0	8.4	20	22	54	97	130	0.4	0.2	0.8	4.2	14.0	5.9	3.0	6.8
Solar, wind, etc.	-	0.0	3.0	219	591	1,173	1,816	0.0	2.3	11	44.7	15.2	7.1	4.5	8.1
Biomass and waste	0.0	11	22	129	236	337	409	0.5	1.4	2.5	11.1	8.9	3.7	1.9	4.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	4,333	7,400	10,696	19,855	27,926	43,063	61,421	4.4	5.0	4.4	3.6	4.3
Population (million)	2,442	2,931	3,401	3,890	4,137	4,406	4,579	1.2	0.9	0.6	0.4	0.6
CO_2 emissions[*2] (Mt)	3,269	4,920	6,989	14,936	15,977	16,376	16,195	4.9	1.0	0.2	-0.1	0.3
GDP per capita ($2010 thousand)	1.8	2.5	3.1	5.1	6.7	9.8	13	3.1	4.1	3.8	3.2	3.6
Primary energy consump. per capita (toe)	0.6	0.7	0.9	1.4	1.5	1.6	1.6	2.9	1.1	0.5	0.4	0.6
Primary energy consumption per GDP[*3]	332	285	273	272	222	162	123	-0.2	-2.9	-3.1	-2.7	-2.9
CO_2 emissions per GDP[*2, *4]	754	665	653	752	572	380	264	0.5	-3.8	-4.0	-3.6	-3.8
CO_2 per primary energy consumption[*2, *5]	2.3	2.3	2.4	2.8	2.6	2.4	2.1	0.7	-1.0	-0.9	-0.9	-0.9
Automobile ownership (million)	48	86	140	322	463	650	861	5.9	5.3	3.4	2.8	3.7
Automobile ownership rates[*6]	19	29	41	83	112	148	188	4.6	4.4	2.8	2.4	3.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A64 China [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	598	871	1,161	3,022	3,367	3,547	3,533	100	100	100	5.6	1.6	0.5	0.0	0.6
Coal	313	528	691	2,045	2,038	1,834	1,515	61	68	43	6.1	0.0	-1.0	-1.9	-1.1
Oil	89	119	221	478	572	638	678	14	16	19	6.2	2.6	1.1	0.6	1.3
Natural gas	12	13	21	140	253	400	491	1.5	4.6	14	11.0	8.8	4.7	2.1	4.8
Nuclear	-	-	4.4	29	117	236	355	-	1.0	10	n.a.	22.1	7.2	4.2	9.7
Hydro	5.0	11	19	78	107	115	122	1.3	2.6	3.5	8.9	4.6	0.7	0.6	1.7
Geothermal	-	-	1.7	4.5	6.4	8.7	10	-	0.1	0.3	n.a.	5.1	3.2	1.6	3.1
Solar, wind, etc.	-	0.0	1.0	32	56	93	136	0.0	1.1	3.9	34.9	8.2	5.2	3.9	5.5
Biomass and waste	180	200	203	216	219	224	227	23	7.1	6.4	0.3	0.2	0.2	0.1	0.2

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	494	664	815	1,814	2,046	2,202	2,277	100	100	100	4.5	1.7	0.7	0.3	0.8
Industry	188	244	329	878	933	907	867	37	48	38	5.7	0.9	-0.3	-0.4	0.0
Transport	24	33	88	245	309	378	433	5.0	14	19	9.1	3.3	2.0	1.4	2.1
Buildings, etc.	272	344	337	548	627	709	740	52	30	33	2.0	2.0	1.2	0.4	1.1
Non-energy use	10	43	62	143	176	208	236	6.5	7.9	10	5.4	3.0	1.7	1.3	1.9
Coal	220	318	304	603	594	509	425	48	33	19	2.8	-0.2	-1.5	-1.8	-1.3
Oil	59	85	181	435	526	590	628	13	24	28	7.4	2.8	1.2	0.6	1.4
Natural gas	6.4	8.9	12	94	145	228	308	1.3	5.2	14	10.8	6.4	4.6	3.0	4.5
Electricity	21	39	89	386	484	575	610	5.9	21	27	10.5	3.3	1.7	0.6	1.7
Heat	7.4	13	25	76	85	87	83	2.0	4.2	3.7	7.9	1.6	0.2	-0.4	0.3
Hydrogen	-	-	-	-	-	-	1.2	-	-	0.1	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	180	200	204	220	212	213	222	30	12	9.7	0.4	-0.5	0.0	0.4	0.0

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	301	621	1,356	5,422	6,681	7,848	8,224	100	100	100	9.9	3.0	1.6	0.5	1.6
Coal	159	441	1,061	4,090	4,189	4,223	3,636	71	75	44	10.2	0.3	0.1	-1.5	-0.4
Oil	82	50	47	6.6	6.5	6.3	6.2	8.1	0.1	0.1	-8.5	-0.3	-0.2	-0.2	-0.2
Natural gas	0.7	2.8	5.8	99	301	534	603	0.4	1.8	7.3	16.9	17.2	5.9	1.2	6.9
Nuclear	-	-	17	112	451	906	1,362	-	2.1	17	n.a.	22.1	7.2	4.2	9.7
Hydro	58	127	222	909	1,247	1,337	1,418	20	17	17	8.9	4.6	0.7	0.6	1.7
Geothermal	-	0.1	0.1	0.1	0.3	0.4	0.5	0.0	0.0	0.0	2.9	15.0	3.7	2.6	6.1
Solar, wind, etc.	-	0.0	0.6	155	390	697	1,019	0.0	2.9	12	51.5	14.1	6.0	3.9	7.2
Biomass and waste	-	-	2.4	50	96	144	179	-	0.9	2.2	n.a.	9.8	4.1	2.1	4.8

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	334	811	2,189	7,513	11,641	19,762	29,180	10.2	6.5	5.4	4.0	5.2
Population (million)	981	1,135	1,263	1,357	1,398	1,410	1,389	0.8	0.4	0.1	-0.1	0.1
CO_2 emissions[*2] (Mt)	1,505	2,339	3,258	9,437	9,857	9,502	8,493	6.3	0.6	-0.4	-1.1	-0.4
GDP per capita ($2010 thousand)	0.3	0.7	1.7	5.5	8.3	14	21	9.3	6.0	5.3	4.1	5.1
Primary energy consump. per capita (toe)	0.6	0.8	0.9	2.2	2.4	2.5	2.5	4.7	1.1	0.4	0.1	0.5
Primary energy consumption per GDP[*3]	1,790	1,073	530	402	289	179	121	-4.2	-4.6	-4.7	-3.9	-4.3
CO_2 emissions per GDP[*2, *4]	4,505	2,882	1,489	1,256	847	481	291	-3.5	-5.5	-5.5	-4.9	-5.3
CO_2 per primary energy consumption[*2, *5]	2.5	2.7	2.8	3.1	2.9	2.7	2.4	0.7	-0.9	-0.9	-1.1	-1.0
Automobile ownership (million)	1.2	5.3	16	127	217	309	398	14.8	8.0	3.6	2.6	4.3
Automobile ownership rates[*6]	1.2	4.7	12	93	155	219	286	13.9	7.5	3.5	2.7	4.2

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A65 India [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	200	307	441	775	987	1,259	1,582	100	100	100	4.1	3.5	2.5	2.3	2.7
Coal	45	94	146	341	416	445	513	31	44	32	5.8	2.9	0.7	1.4	1.5
Oil	33	61	112	176	241	324	396	20	23	25	4.7	4.6	3.0	2.0	3.0
Natural gas	1.3	11	23	44	68	112	174	3.4	5.7	11	6.4	6.3	5.1	4.5	5.2
Nuclear	0.8	1.6	4.4	8.9	21	90	154	0.5	1.2	9.7	7.8	13.1	15.6	5.5	11.1
Hydro	4.0	6.2	6.4	12	16	23	32	2.0	1.6	2.0	3.0	3.8	3.8	3.4	3.6
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	0.2	3.6	12	30	49	0.0	0.5	3.1	29.0	19.0	9.5	4.9	10.1
Biomass and waste	116	133	149	188	212	233	264	44	24	17	1.5	1.7	1.0	1.2	1.3

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	174	243	315	528	667	842	1,049	100	100	100	3.4	3.4	2.4	2.2	2.6
Industry	42	67	83	179	228	288	359	27	34	34	4.4	3.5	2.4	2.2	2.6
Transport	17	21	32	75	107	152	189	8.6	14	18	5.7	5.2	3.6	2.2	3.5
Buildings, etc.	110	142	173	238	283	332	405	59	45	39	2.3	2.5	1.6	2.0	2.0
Non-energy use	5.7	13	27	36	48	70	96	5.5	6.9	9.1	4.5	4.2	3.7	3.2	3.6
Coal	25	39	35	103	122	133	150	16	20	14	4.3	2.4	0.8	1.2	1.4
Oil	27	50	94	150	214	295	366	21	28	35	4.9	5.2	3.3	2.2	3.4
Natural gas	0.7	5.6	9.7	27	35	51	71	2.3	5.0	6.8	7.0	4.2	3.7	3.4	3.7
Electricity	7.8	18	32	77	112	172	250	7.6	14	24	6.4	5.5	4.4	3.8	4.5
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	0.0	0.1	0.3	-	-	0.0	n.a.	n.a.	50.1	9.8	n.a.
Renewables	114	130	144	172	184	192	212	54	32	20	1.2	1.0	0.4	1.0	0.8

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	120	293	570	1,193	1,718	2,591	3,715	100	100	100	6.3	5.3	4.2	3.7	4.3
Coal	61	192	390	869	1,114	1,248	1,535	65	73	41	6.8	3.6	1.1	2.1	2.1
Oil	8.8	13	29	23	23	21	18	4.5	1.9	0.5	2.4	0.0	-1.0	-1.5	-0.9
Natural gas	0.6	10.0	56	65	134	290	545	3.4	5.5	15	8.5	10.9	8.0	6.5	8.2
Nuclear	3.0	6.1	17	34	81	347	591	2.1	2.9	16	7.8	13.1	15.6	5.5	11.1
Hydro	47	72	74	142	184	267	373	24	12	10	3.0	3.8	3.8	3.4	3.6
Geothermal	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Solar, wind, etc.	-	0.0	1.7	37	138	349	569	0.0	3.1	15	35.9	20.7	9.7	5.0	10.6
Biomass and waste	-	-	1.3	23	44	68	85	-	1.9	2.3	n.a.	9.5	4.4	2.4	5.0

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	279	479	825	2,039	3,391	6,462	11,298	6.5	7.5	6.7	5.7	6.5
Population (million)	699	869	1,042	1,252	1,359	1,495	1,599	1.6	1.2	1.0	0.7	0.9
CO_2 emissions[*2] (Mt)	265	546	901	1,894	2,409	2,820	3,377	5.6	3.5	1.6	1.8	2.2
GDP per capita ($2010 thousand)	0.4	0.6	0.8	1.6	2.5	4.3	7.1	4.8	6.3	5.6	5.0	5.6
Primary energy consump. per capita (toe)	0.3	0.4	0.4	0.6	0.7	0.8	1.0	2.5	2.3	1.5	1.6	1.8
Primary energy consumption per GDP[*3]	718	640	535	380	291	195	140	-2.2	-3.8	-3.9	-3.2	-3.6
CO_2 emissions per GDP[*2, *4]	950	1,139	1,092	929	710	436	299	-0.9	-3.8	-4.8	-3.7	-4.1
CO_2 per primary energy consumption[*2, *5]	1.3	1.8	2.0	2.4	2.4	2.2	2.1	1.4	0.0	-0.9	-0.5	-0.5
Automobile ownership (million)	1.7	4.3	9.4	32	59	119	200	9.2	8.9	7.3	5.3	7.0
Automobile ownership rates[*6]	2.4	5.0	9.0	26	43	80	125	7.4	7.6	6.3	4.6	6.0

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A66 Japan [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	345	439	519	455	461	426	388	100	100	100	0.1	0.2	-0.8	-0.9	-0.6
Coal	60	77	97	121	109	105	95	17	27	25	2.0	-1.5	-0.4	-1.0	-0.9
Oil	234	250	255	202	167	139	112	57	45	29	-0.9	-2.7	-1.8	-2.1	-2.2
Natural gas	21	44	66	106	82	80	72	10	23	19	3.9	-3.6	-0.2	-1.0	-1.4
Nuclear	22	53	84	2.4	73	61	56	12	0.5	15	-12.5	62.5	-1.8	-0.7	12.4
Hydro	7.6	7.7	7.5	6.7	7.8	8.4	8.4	1.7	1.5	2.2	-0.6	2.2	0.8	0.0	0.9
Geothermal	0.8	1.6	3.1	2.4	3.9	10	15	0.4	0.5	4.0	1.9	7.0	10.3	4.2	7.1
Solar, wind, etc.	-	1.2	0.8	2.0	3.9	6.6	9.0	0.3	0.4	2.3	2.3	10.0	5.5	3.2	5.8
Biomass and waste	-	4.9	5.7	11	15	17	18	1.1	2.5	4.7	3.6	3.8	1.3	1.0	1.9

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	232	298	341	311	302	278	251	100	100	100	0.2	-0.4	-0.8	-1.0	-0.8
Industry	91	101	96	82	87	85	81	34	26	32	-0.9	0.9	-0.3	-0.5	0.0
Transport	54	72	88	73	66	55	47	24	24	19	0.1	-1.4	-1.8	-1.6	-1.6
Buildings, etc.	58	91	116	118	113	103	90	31	38	36	1.1	-0.6	-0.9	-1.3	-1.0
Non-energy use	28	34	41	38	36	35	33	12	12	13	0.4	-0.9	-0.2	-0.6	-0.5
Coal	25	32	25	26	27	25	23	11	8.3	9.0	-0.9	0.3	-0.5	-1.0	-0.5
Oil	157	182	208	166	148	122	98	61	53	39	-0.4	-1.6	-1.9	-2.2	-1.9
Natural gas	5.8	15	23	34	35	34	32	5.1	11	13	3.5	0.5	-0.3	-0.7	-0.2
Electricity	44	64	81	82	85	86	85	22	26	34	1.0	0.6	0.1	-0.1	0.1
Heat	0.1	0.2	0.5	0.5	3.0	5.1	7.2	0.1	0.2	2.9	4.5	27.3	5.6	3.5	10.0
Hydrogen	-	-	-	-	0.1	0.5	0.9	-	-	0.3	n.a.	n.a.	22.7	6.5	n.a.
Renewables	-	3.9	3.7	3.6	4.2	4.9	5.9	1.3	1.1	2.3	-0.4	2.4	1.6	1.8	1.9

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	573	836	1,049	1,038	1,075	1,060	1,015	100	100	100	0.9	0.5	-0.1	-0.4	-0.1
Coal	55	116	229	337	276	261	226	14	32	22	4.7	-2.8	-0.6	-1.4	-1.5
Oil	265	237	135	150	61	48	40	28	14	3.9	-2.0	-12.0	-2.4	-1.9	-4.8
Natural gas	81	179	256	402	269	275	250	21	39	25	3.6	-5.6	0.2	-0.9	-1.7
Nuclear	83	202	322	9.3	279	233	216	24	0.9	21	-12.5	62.5	-1.8	-0.7	12.4
Hydro	88	89	87	78	91	98	98	11	7.5	9.7	-0.6	2.2	0.8	0.0	0.9
Geothermal	0.9	1.7	3.3	2.6	4.3	12	18	0.2	0.2	1.7	1.8	7.4	10.6	4.2	7.4
Solar, wind, etc.	-	0.0	0.5	19	38	67	93	0.0	1.9	9.1	53.6	10.1	5.7	3.3	5.9
Biomass and waste	-	11	16	41	57	67	74	1.3	3.9	7.3	6.0	4.9	1.6	1.0	2.2

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	2,894	4,553	5,093	5,656	6,561	7,602	8,429	0.9	2.1	1.5	1.0	1.5
Population (million)	117	124	127	127	125	120	114	0.1	-0.2	-0.4	-0.5	-0.4
CO_2 emissions[*2] (Mt)	916	1,070	1,196	1,234	1,029	922	791	0.6	-2.6	-1.1	-1.5	-1.6
GDP per capita ($2010 thousand)	25	37	40	44	52	63	74	0.8	2.4	1.9	1.6	1.9
Primary energy consump. per capita (toe)	3.0	3.6	4.1	3.6	3.7	3.5	3.4	0.0	0.4	-0.4	-0.4	-0.2
Primary energy consumption per GDP[*3]	119	96	102	80	70	56	46	-0.8	-1.9	-2.2	-2.0	-2.0
CO_2 emissions per GDP[*2, *4]	317	235	235	218	157	121	94	-0.3	-4.6	-2.5	-2.5	-3.1
CO_2 per primary energy consumption[*2, *5]	2.7	2.4	2.3	2.7	2.2	2.2	2.0	0.5	-2.8	-0.3	-0.6	-1.1
Automobile ownership (million)	38	58	72	77	77	74	71	1.2	0.0	-0.4	-0.4	-0.3
Automobile ownership rates[*6]	325	467	571	601	611	614	624	1.1	0.2	0.0	0.2	0.1

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A67 ASEAN [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	142	233	380	587	755	1,004	1,268	100	100	100	4.1	3.7	2.9	2.4	2.9
Coal	3.6	13	32	91	121	164	212	5.4	16	17	9.0	4.1	3.1	2.6	3.2
Oil	58	88	153	209	251	312	377	38	36	30	3.8	2.6	2.2	1.9	2.2
Natural gas	8.6	30	74	133	158	197	238	13	23	19	6.7	2.5	2.2	1.9	2.2
Nuclear	-	-	-	-	2.0	27	73	-	-	5.8	n.a.	n.a.	29.7	10.5	n.a.
Hydro	0.8	2.3	4.1	9.4	12	16	19	1.0	1.6	1.5	6.2	3.8	2.6	1.7	2.6
Geothermal	1.8	6.6	18	24	72	128	172	2.8	4.2	14	5.8	16.7	5.9	3.0	7.5
Solar, wind, etc.	-	-	-	0.1	0.6	1.5	3.3	-	0.0	0.3	n.a.	22.7	9.3	8.2	12.2
Biomass and waste	70	93	99	118	137	155	169	40	20	13	1.0	2.1	1.3	0.8	1.3

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	112	173	271	425	516	656	811	100	100	100	4.0	2.8	2.4	2.1	2.4
Industry	22	43	76	116	146	196	251	25	27	31	4.5	3.4	2.9	2.5	2.9
Transport	17	32	62	112	135	174	217	19	26	27	5.5	2.8	2.5	2.3	2.5
Buildings, etc.	71	87	113	143	166	200	237	50	34	29	2.2	2.2	1.8	1.7	1.9
Non-energy use	2.4	11	21	53	67	87	106	6.3	13	13	7.1	3.4	2.6	2.0	2.6
Coal	2.1	6.0	13	27	33	41	48	3.5	6.4	5.9	6.7	2.9	2.2	1.5	2.1
Oil	41	67	123	194	237	298	362	38	46	45	4.8	3.0	2.3	2.0	2.3
Natural gas	2.5	7.5	17	40	51	70	92	4.4	9.4	11	7.5	3.4	3.3	2.8	3.1
Electricity	4.7	11	28	61	82	124	176	6.4	14	22	7.7	4.3	4.1	3.6	4.0
Heat	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Hydrogen	-	-	-	-	-	-	-	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	62	82	90	103	112	124	133	47	24	16	1.0	1.3	1.0	0.7	1.0

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	62	154	370	786	1,048	1,562	2,211	100	100	100	7.3	4.2	4.1	3.5	3.9
Coal	3.0	28	79	255	348	519	733	18	32	33	10.1	4.6	4.1	3.5	4.0
Oil	47	66	72	43	37	36	35	43	5.5	1.6	-1.8	-2.1	-0.2	-0.5	-0.8
Natural gas	0.7	26	154	349	426	572	739	17	44	33	11.9	2.9	3.0	2.6	2.8
Nuclear	-	-	-	-	7.7	104	280	-	-	13	n.a.	n.a.	29.7	10.5	n.a.
Hydro	9.8	27	47	109	142	184	219	18	14	9.9	6.2	3.8	2.6	1.7	2.6
Geothermal	2.1	6.6	16	19	49	84	110	4.3	2.4	5.0	4.7	14.6	5.4	2.8	6.7
Solar, wind, etc.	-	-	-	1.7	7.1	17	38	-	0.2	1.7	n.a.	22.7	9.3	8.2	12.2
Biomass and waste	-	0.6	1.0	10	30	46	57	0.4	1.3	2.6	13.0	16.8	4.4	2.1	6.6

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	405	703	1,137	2,190	3,097	4,848	7,019	5.1	5.1	4.6	3.8	4.4
Population (million)	345	427	503	594	640	693	732	1.4	1.1	0.8	0.5	0.8
CO_2 emissions[*2] (Mt)	205	362	710	1,162	1,424	1,816	2,247	5.2	2.9	2.5	2.1	2.5
GDP per capita ($2010 thousand)	1.2	1.6	2.3	3.7	4.8	7.0	9.6	3.6	4.0	3.7	3.2	3.6
Primary energy consump. per capita (toe)	0.4	0.5	0.8	1.0	1.2	1.4	1.7	2.6	2.6	2.1	1.8	2.1
Primary energy consumption per GDP[*3]	352	332	334	268	244	207	181	-0.9	-1.3	-1.6	-1.4	-1.5
CO_2 emissions per GDP[*2, *4]	507	515	624	531	460	375	320	0.1	-2.0	-2.0	-1.6	-1.9
CO_2 per primary energy consumption[*2, *5]	1.4	1.6	1.9	2.0	1.9	1.8	1.8	1.1	-0.7	-0.4	-0.2	-0.4
Automobile ownership (million)	4.4	10	21	52	70	96	130	7.4	4.3	3.3	3.0	3.4
Automobile ownership rates[*6]	13	24	41	87	109	139	177	5.9	3.2	2.4	2.5	2.6

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A68 United States [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	1,805	1,915	2,273	2,188	2,130	1,988	1,755	100	100	100	0.6	-0.4	-0.7	-1.2	-0.8
Coal	376	460	534	432	348	238	128	24	20	7.3	-0.3	-3.1	-3.7	-6.0	-4.4
Oil	797	757	871	780	739	641	523	40	36	30	0.1	-0.8	-1.4	-2.0	-1.5
Natural gas	477	438	548	610	626	595	492	23	28	28	1.4	0.4	-0.5	-1.9	-0.8
Nuclear	69	159	208	214	216	223	252	8.3	9.8	14	1.3	0.1	0.3	1.2	0.6
Hydro	24	23	22	23	24	25	25	1.2	1.1	1.4	0.0	0.6	0.2	0.1	0.3
Geothermal	4.6	14	13	8.6	21	44	56	0.7	0.4	3.2	-2.1	13.9	7.4	2.4	7.1
Solar, wind, etc.	-	0.3	2.1	18	37	73	118	0.0	0.8	6.7	19.0	11.1	7.1	5.0	7.3
Biomass and waste	54	62	73	97	113	145	157	3.3	4.4	9.0	2.0	2.2	2.5	0.8	1.8

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	1,311	1,294	1,546	1,495	1,467	1,380	1,228	100	100	100	0.6	-0.3	-0.6	-1.2	-0.7
Industry	387	284	332	261	256	232	203	22	17	16	-0.4	-0.3	-1.0	-1.3	-0.9
Transport	425	488	588	608	594	551	477	38	41	39	1.0	-0.3	-0.8	-1.4	-0.9
Buildings, etc.	397	403	473	507	491	457	405	31	34	33	1.0	-0.5	-0.7	-1.2	-0.8
Non-energy use	102	119	153	119	125	140	144	9.2	8.0	12	0.0	0.7	1.1	0.2	0.7
Coal	56	56	33	22	24	20	16	4.3	1.5	1.3	-3.9	0.9	-1.7	-2.3	-1.3
Oil	689	683	793	731	688	597	487	53	49	40	0.3	-0.9	-1.4	-2.0	-1.5
Natural gas	337	303	360	333	338	312	276	23	22	23	0.4	0.2	-0.8	-1.2	-0.7
Electricity	174	226	301	325	330	337	323	18	22	26	1.6	0.2	0.2	-0.4	0.0
Heat	-	2.2	5.3	5.9	6.2	5.7	5.1	0.2	0.4	0.4	4.5	0.7	-0.8	-1.0	-0.5
Hydrogen	-	-	-	-	0.0	4.5	8.4	-	-	0.7	n.a.	n.a.	67.8	6.4	n.a.
Renewables	54	23	54	77	80	104	112	1.8	5.2	9.1	5.4	0.4	2.7	0.7	1.4

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	2,427	3,203	4,026	4,287	4,354	4,465	4,310	100	100	100	1.3	0.2	0.3	-0.4	0.0
Coal	1,243	1,700	2,129	1,712	1,395	967	489	53	40	11	0.0	-2.9	-3.6	-6.6	-4.5
Oil	263	131	118	37	28	17	6.3	4.1	0.9	0.1	-5.4	-3.8	-5.0	-9.4	-6.3
Natural gas	370	382	634	1,158	1,230	1,241	877	12	27	20	4.9	0.9	0.1	-3.4	-1.0
Nuclear	266	612	798	822	830	855	965	19	19	22	1.3	0.1	0.3	1.2	0.6
Hydro	279	273	253	271	283	290	293	8.5	6.3	6.8	0.0	0.6	0.2	0.1	0.3
Geothermal	5.4	16	15	18	46	94	119	0.5	0.4	2.8	0.6	13.8	7.5	2.4	7.1
Solar, wind, etc.	-	3.7	6.4	190	410	834	1,370	0.1	4.4	32	18.6	11.6	7.4	5.1	7.6
Biomass and waste	0.5	86	72	78	132	167	192	2.7	1.8	4.5	-0.4	7.8	2.3	1.4	3.4

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	6,514	9,056	12,713	15,902	18,932	23,986	28,725	2.5	2.5	2.4	1.8	2.2
Population (million)	227	250	282	316	332	355	373	1.0	0.7	0.6	0.5	0.6
CO_2 emissions[*2] (Mt)	4,743	4,820	5,617	5,184	4,744	3,893	2,848	0.3	-1.3	-2.0	-3.1	-2.2
GDP per capita ($2010 thousand)	29	36	45	50	57	68	77	1.4	1.8	1.7	1.3	1.6
Primary energy consump. per capita (toe)	7.9	7.7	8.1	6.9	6.4	5.6	4.7	-0.4	-1.1	-1.3	-1.7	-1.4
Primary energy consumption per GDP[*3]	277	211	179	138	113	83	61	-1.9	-2.8	-3.0	-3.0	-3.0
CO_2 emissions per GDP[*2, *4]	728	532	442	326	251	162	99	-2.1	-3.7	-4.3	-4.8	-4.3
CO_2 per primary energy consumption[*2, *5]	2.6	2.5	2.5	2.4	2.2	2.0	1.6	-0.3	-0.9	-1.3	-1.9	-1.4
Automobile ownership (million)	156	189	221	253	272	301	323	1.3	1.1	1.0	0.7	0.9
Automobile ownership rates[*6]	686	756	785	799	819	848	867	0.2	0.3	0.3	0.2	0.3

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Table A69 European Union [Advanced Technologies Scenario]

Primary energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total[*1]	n.a.	1,645	1,692	1,626	1,578	1,471	1,324	100	100	100	-0.1	-0.4	-0.7	-1.0	-0.8
Coal	n.a.	456	321	286	232	168	127	28	18	9.6	-2.0	-3.0	-3.1	-2.7	-3.0
Oil	n.a.	606	623	513	463	395	326	37	32	25	-0.7	-1.5	-1.6	-1.9	-1.7
Natural gas	n.a.	297	396	387	378	336	282	18	24	21	1.2	-0.3	-1.2	-1.7	-1.2
Nuclear	n.a.	207	246	229	233	263	255	13	14	19	0.4	0.3	1.2	-0.3	0.4
Hydro	n.a.	25	31	32	32	33	33	1.5	2.0	2.5	1.1	0.3	0.2	0.0	0.1
Geothermal	n.a.	3.2	4.6	5.9	7.3	10	12	0.2	0.4	0.9	2.7	3.1	3.5	1.3	2.6
Solar, wind, etc.	n.a.	0.3	2.4	31	47	64	80	0.0	1.9	6.0	23.2	6.3	3.0	2.3	3.6
Biomass and waste	n.a.	47	66	140	183	199	205	2.8	8.6	15	4.9	3.9	0.8	0.3	1.4

Final energy consumption

	Mtoe							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	n.a.	1,130	1,176	1,139	1,109	1,017	904	100	100	100	0.0	-0.4	-0.9	-1.2	-0.9
Industry	n.a.	343	308	258	261	252	236	30	23	26	-1.2	0.2	-0.3	-0.6	-0.3
Transport	n.a.	259	304	303	290	250	207	23	27	23	0.7	-0.6	-1.5	-1.9	-1.4
Buildings, etc.	n.a.	429	453	478	447	398	341	38	42	38	0.5	-1.0	-1.1	-1.5	-1.2
Non-energy use	n.a.	99	111	100	111	117	120	8.7	8.8	13	0.1	1.6	0.5	0.2	0.7
Coal	n.a.	122	52	38	35	29	23	11	3.4	2.6	-4.9	-1.2	-1.8	-2.1	-1.8
Oil	n.a.	503	540	463	420	359	296	45	41	33	-0.4	-1.4	-1.6	-1.9	-1.7
Natural gas	n.a.	226	272	266	262	244	215	20	23	24	0.7	-0.2	-0.7	-1.2	-0.8
Electricity	n.a.	186	218	238	246	246	239	16	21	26	1.1	0.5	0.0	-0.3	0.0
Heat	n.a.	54	45	48	45	41	36	4.8	4.2	3.9	-0.5	-0.8	-1.1	-1.4	-1.1
Hydrogen	n.a.	-	-	-	n.a.	n.a.	n.a.	-	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Renewables	n.a.	39	49	85	100	98	95	3.5	7.5	11	3.5	2.4	-0.2	-0.3	0.4

Electricity generation

	(TWh)							Shares (%)			CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990	2013	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
Total	n.a.	2,576	3,005	3,230	3,349	3,394	3,344	100	100	100	1.0	0.5	0.1	-0.1	0.1
Coal	n.a.	1,050	968	905	715	493	355	41	28	11	-0.6	-3.3	-3.6	-3.2	-3.4
Oil	n.a.	224	181	61	39	21	12	8.7	1.9	0.4	-5.5	-6.1	-6.1	-5.4	-5.9
Natural gas	n.a.	193	480	507	498	386	267	7.5	16	8.0	4.3	-0.3	-2.5	-3.6	-2.4
Nuclear	n.a.	795	945	877	893	1,010	979	31	27	29	0.4	0.3	1.2	-0.3	0.4
Hydro	n.a.	290	356	371	378	384	384	11	11	11	1.1	0.3	0.2	0.0	0.1
Geothermal	n.a.	3.2	4.8	5.9	7.5	11	12	0.1	0.2	0.4	2.7	3.4	3.7	1.3	2.7
Solar, wind, etc.	n.a.	1.3	24	324	533	730	923	0.1	10	28	27.1	7.4	3.2	2.4	4.0
Biomass and waste	n.a.	20	46	178	285	358	410	0.8	5.5	12	10.1	7.0	2.3	1.3	3.1

Energy and economic indicators

								CAGR (%)				
	1980	1990	2000	2013	2020	2030	2040	1990/ 2013	2013/ 2020	2020/ 2030	2030/ 2040	2013/ 2040
GDP ($2010 billion)	n.a.	11,862	14,721	17,159	19,411	22,767	25,759	1.6	1.8	1.6	1.2	1.5
Population (million)	n.a.	478	488	507	516	523	526	0.3	0.3	0.1	0.0	0.1
CO_2 emissions[*2] (Mt)	n.a.	4,068	3,783	3,320	2,894	2,318	1,811	-0.9	-1.9	-2.2	-2.4	-2.2
GDP per capita ($2010 thousand)	n.a.	25	30	34	38	44	49	1.4	1.5	1.5	1.2	1.4
Primary energy consump. per capita (toe)	n.a.	3.4	3.5	3.2	3.1	2.8	2.5	-0.3	-0.7	-0.8	-1.1	-0.9
Primary energy consumption per GDP[*3]	n.a.	139	115	95	81	65	51	-1.6	-2.2	-2.3	-2.3	-2.2
CO_2 emissions per GDP[*2, *4]	n.a.	343	257	193	149	102	70	-2.5	-3.7	-3.7	-3.6	-3.7
CO_2 per primary energy consumption[*2, *5]	n.a.	2.5	2.2	2.0	1.8	1.6	1.4	-0.8	-1.5	-1.5	-1.4	-1.5
Automobile ownership (million)	n.a.	177	235	294	319	345	358	2.2	1.2	0.8	0.4	0.7
Automobile ownership rates[*6]	n.a.	371	482	580	619	660	681	2.0	0.9	0.6	0.3	0.6

*1 Trade of electricity and heat are not shown, *2 Excludes emission reduction by CCS, *3 toe/$2010 million,
*4 t/$2010 million, *5 t/toe, *6 Vehicles per 1,000 people

Contact :report@tky.ieej.or.jp