

Asia/World Energy Outlook 2012

—Increasing Significance of Asia and the Middle East, and their Interdependence—

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Outline of the Study

This study analyzes the energy supply and demand in Asia and the world, based on a long-term standpoint, while considering the changes in the international energy situation, world economic trends, the development of emerging nations particularly in Asia, the trend of energy policy, and countermeasures against global warming. The analysis focuses on the Middle East, a major oil and gas producer, as well as on Asian countries. The energy mix and the 3Es (energy security, environmental protection and economic efficiency/rationality) in these two regions in 2035 were quantitatively assessed based on the analysis results.

Low-carbon technologies for promoting efficient energy use and restricting fossil fuel consumption are expected to play bigger roles in the years to come, both in terms of ensuring a stable energy supply and coping with global warming. Therefore, the Reference Scenario, which integrates past trends and current energy/environmental policies, was established in this study, and the energy supply and demand situation until 2035 was analyzed. Then, the Advanced Technology Scenario, in which advanced low-carbon technologies are strongly promoted and expanded worldwide, was established for comparative analysis.

Major Conclusions

■ Increase in energy demand in Asia to account for 60% of the world's total increase

In the Reference Scenario, the world's primary energy consumption will increase from 11.7 Btoe (billion tons of oil equivalent) in 2010 to 17.5 Btoe in 2035. The demand increase in Asia will be particularly significant, accounting for 60% of the world total increase of 5.8 Btoe. Two major economies in Asia, China and India, will show an especially remarkable growth in demand. The demand increase of both countries until 2035 is expected to be a total of 2.6 Btoe, accounting for 45% of the world's total increase. The competition for resources is likely to intensify as the dependence on energy imports rises with the increase in energy demand in Asia.

■ Even in 2035, fossil fuel will dominate the energy demand in Asia

Renewable energy sources such as photovoltaic power and wind power and also nuclear power will be actively promoted to meet the increasing energy demand in Asia. In the Reference Scenario, the shares of renewable energy and nuclear energy in the primary energy will increase from 3.0% and 6.1% in 2010, to 5.1% and 6.2% in 2035, respectively. However, even in 2035, fossil fuel will account for most of the energy demand in Asia, with an energy mix of 46% coal, 26% oil and 17% gas. Among the various types of fossil fuel, the growth of natural gas consumption will be significant, with an average annual growth rate from 2010 to 2035 of 4.3%.

■ Energy demand in the Middle East will also increase dramatically

In the Middle East, the world's largest fossil fuel exporter, domestic energy demand will expand rapidly by 1.8 times from 630 million toe in 2010 to 1,140 million toe in 2035. For example, the domestic oil consumption in 2035 in Saudi Arabia is projected to increase to around 44% of the current oil production in the country. Therefore, net exports may decrease unless production capability is expanded. Thus, the increasing domestic demand in the Middle East will require further investment in upstream development to meet the increasing demand in Asia and the Middle East. Under these circumstances, it is important to promote energy conservation and also to introduce renewable and nuclear energies in the Middle East.

■ Energy supply and demand in Asia will change significantly by technological development

The introduction of advanced energy technologies will significantly change the energy supply and demand situation in Asia. The primary energy demand in Asia in 2035 is forecast to be 6.4 Btoe in the Advanced Technology Scenario, 17% lower than the Reference Scenario. The shares of renewable energy and nuclear power in the energy mix in Asia in 2035 in the Advanced Technology Scenario will reach 5.2% and 10%, respectively (2.8% and 5.5% in the Reference Scenario), and thus the total share of non-fossil fuel energy will increase to 20.4% (11.4% in the Reference Scenario). As a result, CO₂ emissions in Asia in 2035 are estimated to be 13.7 Gt in the Advanced Technology Scenario, 36% (7.6 Gt) lower than the Reference Scenario.

■ Increasing importance of 3E+S

The significant increase in energy demand, especially fossil fuel energy, could be a crucial factor that prevents sustainable, stable development of the international energy market with lower environmental burden. It is important to enhance efforts with a mid- to long-term and global perspective based on the so-called 3Es (energy security, environmental protection and economic efficiency) and S (safety: safe use of energy) in order to solve the problem. Unfortunately, there is no easy way to do this. Therefore, it is important to take every conceivable measure to make a breakthrough, including further energy conservation on the demand side and utilization of safer nuclear energy, cleaner fossil fuel and cheaper renewable energy on the supply side.

■ Challenges of 3E+S in Asia and the Middle East

The 3E+S will become increasingly significant also in the energy supply and demand in Asia and the Middle East. Above all, energy conservation will play a key role. In the energy mix, the introduction of both renewable energy and nuclear energy will reinforce energy security through diversification of energy sources, as well as assist environmental protection through the reduction of fossil fuel consumption.

(1) Energy security

The energy self-sufficiency rate in Asia is projected to decline from the current 85% to 70–75% in 2035 due to increased energy demand. Therefore, it will be important to develop domestically-produced energy and to diversify energy sources, and also to promote energy conservation for ensuring a stable energy supply in Asia. It is also important to effectively utilize

abundant coal in Asia, and so advanced technologies for reducing the environmental burden of coal are required.

There is also an urgent need to ensure a stable supply of oil and natural gas in Asia. Therefore, it will be important to enhance the relationships with resource-rich countries while diversifying the sources of supply. Above all, the stable increase of production in the Middle East will be crucial for the energy supply in Asia. The importance of Asia for the Middle East will grow as a major oil and gas export destination, in contrast to North America which is going to achieve energy self-sufficiency and Europe where oil and gas demand growth will remain low; thus, the mutual dependence between Asia and the Middle East will deepen.

Furthermore, the utilization of renewable energy and nuclear energy will be promoted in view of their advantage as domestically-produced energies, to satisfy the increasing demand for electricity and also to diversify energy sources and break away from excessive dependence on coal.

(2) Environmental protection

A substantial reduction of CO₂ can be achieved by using advanced technologies in Asia, the largest CO₂ emitter in the world. Technological development could reduce emissions by 7.2 Gt, corresponding to nearly 20% of global CO₂ emissions in 2035 (43.4 Gt) in the Reference Scenario solely within the developing countries in Asia. To accomplish this goal, all possible measures must be taken. Above all, energy conservation (including efficient use of fossil fuel) delivers the largest effect. CO₂ emissions in Asia could be reduced by around 50% by energy conservation with advanced technologies. This is followed by the introduction of nuclear and renewable energy, which would also have a significant effect on reducing CO₂ emissions. In the long run, carbon capture and storage (CCS) could also have a considerable impact.

(3) Economic efficiency

Energy conservation is an extremely effective way to pursue efficiency and rationality of energy utilization. According to estimates of respective economic benefits, based on a comparison of the necessary investment and the reduction of fossil fuel imports provided by such investment for each energy option, energy conservation and nuclear power would provide cumulative merits of \$1.9 trillion and \$0.6 trillion up to 2035, respectively, in non-OECD Asia. On the other hand, renewable energy would place a financial burden of up to \$2.4 trillion. Therefore, it is essential to reduce the cost of renewable energy. Meanwhile, fluctuations in fossil fuel prices will have a larger influence on the financial burden. If, for example, crude oil and natural gas prices rise by 30%, it will cause an additional burden (increase of imports) of \$5.7 trillion. Fluctuations in energy prices affect the national economy more directly in the Middle East, so it is critical for both resource-producing countries and consuming countries to stabilize energy prices at an appropriate level. From this viewpoint, introducing nuclear and renewable energy in Asia is at least as important as their own economic efficiency, for reducing the risk of a sharp rise of fossil fuel prices and reinforcing bargaining power.

(4) Safety

A number of new nuclear power plants are planned or under construction in many countries,

especially in Asia and the Middle East. The total installed capacity of nuclear power in the world is projected to expand from the current 384 GW (2011) to 572 GW, an increase of 49% in 2035 in the Reference Scenario, and to 471 GW, an increase of 23% even if nuclear power stagnates (a Low Nuclear Scenario). Particularly, the installed capacity of nuclear power in Asia is forecast to increase remarkably from 86.8 GW in 2011 to 223 GW in 2035 in the Reference Scenario. Consequently, countries with advanced technologies, including Japan, need to actively contribute to establishing the safety management system in Asia through international cooperation.

■ Outlook through 2050

Global CO₂ emissions in 2050 in the Advanced Technology Scenario would decline by 23% from the 2005 level (nearly the same level as 1990). It is necessary to develop and promote new innovative technologies in order to accomplish the target of reducing global GHG emissions by half by 2050, in addition to introducing technologies for reducing CO₂ which are expected to be commercialized in the future. The Low Nuclear Scenario where the use of nuclear power slows down would make it even more difficult to reduce greenhouse gas emissions significantly. In new technological innovation, it is required to invest more heavily in R&D in nuclear power generation, renewable energy, CCS and other energy conservation technologies to achieve dramatic breakthroughs and widespread use.

■ Implications for Japan

It is particularly important for a resource-poor country like Japan to assure energy security. A stable international energy market is essential for Japan. Regarding the procurement of fossil fuel, mid- to long-term international cooperation, especially closer cooperation and coordination with other countries in Asia as net energy-consuming nations, is vital. It is also necessary to diversify supply sources, including procuring LNG from North America and Russia, while trying to maintain and reinforce relationships with resource producers such as the Middle East nations.

Concerning environmental issues, it is important to establish more effective and efficient methods of reducing CO₂ emissions globally, in addition to domestic efforts; there are greater potential opportunities for doing so in developing countries than in Japan. Therefore, Japan should search for effective means of cooperation especially in Asia.

Regarding safety, Japan must make international contributions for securing nuclear safety by establishing international standards for safety regulations, transferring safety techniques and developing human resources, based on the lessons learned from the Fukushima accident, especially since nuclear power generation is likely to increase dramatically in Asia.

Japan has a major role to play for the accomplishment of the 3E+S in Asia. It is necessary to develop and utilize energy conservation and environmental protection technologies, a field where Japan excels. Enhanced efforts to achieve the 3E+S should be a major pillar in Japan's future strategy for growth and the international energy strategy.

Outline of the Forecasts

Major premises

● Economic growth

World: World economic growth slowed down after the Lehman Shock in 2008, but has overcome the worst partly thanks to the economic measures taken by each country after the crisis. Although many risks, such as the Greek debt crisis, remain along the way to full-fledged economic recovery, the world economy is expected to grow steadily led by emerging countries in Asia in the mid to long term. Moderate but stable annual growth of about 2.9% is expected between 2010 and 2035.

Asia: Economic growth in Asia (excluding Japan) is projected to be 5.2%, and Asia thus leads the world economy. China and India will grow respectively at 5.7% and 6.5%, increasing their presence in the world economy.

● Population

The world population will increase from 6.8 billion in 2010 to 8.6 billion in 2035. China's population will reach 1.38 billion and that of India will reach 1.58 billion; the population of Asia as a whole will reach 4.5 billion, accounting for 52% of the world population.

● Crude oil prices

Crude oil prices (import CIF price of Japan, 2011 price) will rise from \$109/barrel in 2011 to \$115 in 2020, \$122 in 2030 and \$125 in 2035.

● Setting of the scenarios

In the Reference Scenario which serves as a standard for the analysis, highly probable policies and technical development are assumed. In the Advanced Technology Scenario, innovative technologies and technological development will spread worldwide to reinforce energy security and countermeasures against global warming.

Results of major calculations (Reference Scenario)

● World

Primary energy consumption

The world primary energy consumption is forecast to increase at an annual rate of 1.6% up to 2035, from 11.7 Btoe (billion tons of oil equivalent) in 2010 to 17.5 Btoe in 2035 (an increase of 49%). The share of fossil fuel in the primary energy consumption will shift from 88% in 2010 to 85% in 2035, and fossil fuel will account for 79% of the increase in primary energy consumption up to 2035. Thus, fossil fuel will continue to be a major energy source in the future.

The oil demand will increase by 30 million B/D, from 84 million B/D in 2010 to 114 million B/D in 2035, and will remain the most important energy source with a share of 32% (annual increase of 1.2%). It will decrease 0.5% annually in OECD countries, but increase 2.4% annually in developing countries. Natural gas demand will grow most (2.0%) among fossil fuels. It will expand from 2.1 billion tons of LNG in 2010 to 3.4 billion tons in 2035. Demand for coal will increase at an annual rate of 1.4% mainly for power generation, rising from 5 Btce (billion tons of coal equivalent: 1 tce = 0.7 toe) in 2010 to 7 Btce in 2035.

Renewable energy (wind power, solar power, etc.)

The total installed capacity of global photovoltaic power generation will rapidly increase by a factor of 14, from 39 GW in 2010 to 525 GW in 2035. On the other hand, the total installed capacity of global wind power generation will increase fivefold from 184 GW in 2010 to 859 GW in 2035. However, partly because of their low capacity factors, the total share of PV and wind power generation in the total global power generation was 1.7% in 2010, and will be only 5.4% even in 2035. The rate of renewable energy (excluding hydropower) in the world primary energy consumption will increase from 3.6% in 2010 to 6.3% in 2035.

Nuclear power

The total installed capacity worldwide of nuclear power generation facilities will increase from 384 GW in 2011 to 572 GW in 2035. The share of nuclear power generation in the total global power generation will shift from 13% in 2010 to 11% in 2035.

● Asia

Primary energy consumption

The primary energy consumption in Asia is projected to increase at an annual rate of 2.5%, and 61% of the increase in the world's primary energy consumption until 2035 is attributed to Asia (of which China and India account for 45 percentage points). Fossil fuel accounts for 84% of the increase in Asia, of which 37% is coal, 23% is oil and 24% is natural gas. Especially, coal consumption in Asia will grow remarkably, accounting for 94% of the total world increase in coal consumption.

Supply and demand of oil

The demand for oil is increasing in Asia with the progress of industrialization and motorization. On the other hand, as oil production in the region is growing at a sluggish pace, net oil imports in Asia will expand from 790 Mtoe (790 million toe; 16.2 million B/D) in 2010 to 1,590 Mtoe (32.6 million B/D) in 2035. The dependence on oil imports will rise from 67% to 80%.

Progress of electrification and supply of electricity

Electrification is progressing in Asia due to rising income levels and urbanization, and electricity consumption will increase 2.3 fold in the next 25 years. The power to cover this increase in demand will come mainly from resource-abundant and economically efficient coal-fired thermal power (share in the total power generation: 56%). Natural gas-fired thermal power generation with high power generation efficiency will also expand steadily, with the output-based share increasing from 13% in 2010 to 17% in 2035. Moreover, nuclear power generation will rapidly increase in Asia: 137 GW of the total global increase in installed capacity of 183 GW will be constructed in Asia (the share in power generation will increase from 7.3% to 9.0% in 2035).

Progress of motorization

Motorization is spreading in the emerging countries of Asia as income levels rise. Automobile ownership in Asia will increase from 240 million in 2010 to 690 million in 2035. In spite of the spread of clean energy vehicles and further improvements in fuel economy, oil consumption in Asia will expand from 24.0 million B/D in 2010 to 40.7 million B/D in 2035 partly because of increased oil consumption in other sectors.

● CO₂ emissions

With the increase of fossil fuel consumption, global CO₂ emissions will grow from 30.4 Gt in 2010 to 35.7 Gt in 2020 (up 68% from the 1990 level), and further expand to 43.4 Gt in 2035 (up 104% from the 1990 level). CO₂ emissions in Asia will increase by 70% from 12.5 Gt in 2010 to 21.3 Gt in 2035. The increase in Asia accounts for 68% of the total growth in the whole world, and the increase in China alone accounts for approximately 30% of the total increase in the world.

● The Middle East

Primary energy demand will also expand rapidly in the Middle East, increasing 80% from 630 Mtoe in 2010 to 1,140 Mtoe in 2035. Such a rapid increase is expected to greatly affect the energy supply and demand in each country. For example, oil consumption in Saudi Arabia is expected to nearly double by 2035. The ratio of domestic oil consumption to crude oil production in the country is currently 22%; assuming the same level of crude oil production in 2035, the ratio is expected to rise to as high as 44% by 2035. Therefore, the country must secure a margin for fossil fuel exports in the long run.

Results of major calculations (Advanced Technology Scenario)

● Impact of technological development in the world

In the Advanced Technology Scenario, it is assumed that innovative technologies continue to spread in the world, in the context of assuring a stable energy supply, reinforcing countermeasures against global warming and promoting international cooperation and transfer of technologies. Specifically, there will be improvements in the efficiency of diverse industrial processes and electric appliances, diffusion of such technologies as clean-energy vehicles, biofuel, clean coal technology, nuclear power and carbon capture and storage (CCS). Such technological development and diffusion are regarded as feasible long-term targets if those countries with advanced technologies such as Japan engage in international cooperation.

World: In the Advanced Technology Scenario, the global primary energy consumption in 2035 will decline by 2.5 Btoe (down 14%) from the Reference Scenario. The amount of energy conservation corresponds to approximately five times as much as the total energy consumption in Japan in 2010 (500 Mtoe). Of this 2.5 Btoe of energy conserved, OECD countries account for 0.8 Btoe and non-OECD countries for 1.7 Btoe. Thus, energy conserved in non-OECD countries is approximately 2.1 times as large as that in OECD countries. The share of non-fossil fuel energy sources in 2035 will increase from 15% in the Reference Scenario to 23% in the Advanced Technology Scenario.

The consumption of oil, natural gas and coal will be cut by 820 Mtoe (15%), 900 Mtoe (20%) and 1,600 Mtoe (33%) in 2035, respectively. The consumption of natural gas will continue to grow even in the Advanced Technology Scenario, while the consumption of oil will reach a peak after 2030. The consumption of coal will fall the most among fossil fuels due to fuel switching and efficiency improvements in the power generation sector.

Asia: The primary energy consumption in Asia in 2035 will decline by 1.3 Btoe (down 17%) from the Reference Scenario. The amount of energy conservation corresponds to approximately 2.6 times as much as the total energy consumption in Japan in 2010. The energy saving in Asia is extremely important because 1.3 Btoe of energy conserved in Asia accounts for more than 50% of the energy

conserved in the whole world (2.5 Btoe). Also, in the Advanced Technology Scenario, the share of non-fossil fuel energy in 2035 will increase from 11% in the Reference Scenario to 20%. The consumption of oil, natural gas and coal will fall by 340 Mtoe (17%), 250 Mtoe (19%) and 1,200 Mtoe (33%) in 2035, respectively. The consumption of oil and natural gas will continue to grow even in the Advanced Technology Scenario, while the consumption of coal will fall significantly and the consumption of oil will reach a peak.

The Middle East: In the Advanced Technology Scenario, primary energy consumption in 2035 will be reduced by 130 Mtoe (12%) from the Reference Scenario. How to encourage energy saving in the Middle East is an important issue for the future because energy saving effects in this region are significant.

● Impact on CO₂ emissions

World: Although global CO₂ emissions will increase by 4.7 Gt (up 17% from the 2005 level) between 2005 and 2020, they will reach a peak in the 2020s thanks to further progress in energy and environmental technologies. Global CO₂ emissions in 2035 will decrease by 13.7 Gt (down 31%). The amount of decrease corresponds to approximately 12 times the CO₂ emissions of Japan in 2010. Of this CO₂ emissions reduction of 13.7 Gt, 4.2 Gt will come from developed countries while 9.5 Gt will come from developing countries, thus the reduction in developing countries will be more than double that in developed countries. The reduction in Asia will be 7.6 Gt, accounting for 56% of the total global reduction. As a result, the CO₂ reduction potential of Asia is highly significant.

Asia: CO₂ emissions in Asia will reach a peak in the late 2020s thanks to technological progress. In 2035, CO₂ emissions in Asia will decrease by 7.6 Gt (down 36%). The amount of decrease corresponds to approximately seven times the CO₂ emissions of Japan in 2010. Of this CO₂ emissions reduction of 7.6 Gt, 4.2 Gt will come from China, 1.5 Gt from India, and 1.9 Gt from other countries.

The role of technology: All technological options are important because the combination of diverse advanced technologies results in deeper CO₂ emissions reduction. Of the CO₂ emissions reduction of 13.7 Gt in the world in 2035, 6.2 Gt will come from energy conservation (45% of the total), 1.6 Gt from nuclear energy (11%), 1.7 Gt from renewable energy (13%), 1.3 Gt from fuel conversion (10%), and 2.6 Gt from carbon capture and storage (CCS) technology (19%). Of the CO₂ emissions reduction of 7.6 Gt in Asia in 2035, 3.7 Gt will come from energy conservation (48%), 0.9 Gt from nuclear energy (12%), 0.7 Gt from renewable energy (10%), 0.8 Gt from fuel conversion (10%), and 1.4 Gt from CCS (18%). Thus, energy conservation, nuclear energy, renewable energy, fuel conversion and CCS are crucial for reducing carbon emissions in the field of energy supply and demand.

● Influence of stagnation of nuclear development

Prospects for installed capacity of power generation facilities assuming the stagnation of nuclear development: Even if the utilization of nuclear energy significantly stagnates in many countries due to political changes since the Fukushima accident, the countries that are promoting nuclear energy including the U.S., France and Russia, and also emerging countries including China and India, will continue their nuclear power generation policies. In a “Low Nuclear Scenario”, the current installed capacity of 389 GW will expand to 471 GW in 2035, 100 GW short of the Reference Scenario.

Influence on CO₂ emissions and consumption of fossil fuel: If the decrease of nuclear power generation in the “Low Nuclear Scenario” is substituted by thermal power, global CO₂ emissions in 2035 will increase by 1.4 Gt (5%) compared to the Advanced Technology Scenario. Meanwhile, the consumption of coal will increase by approximately 350 Mtce (240 Mtoe), oil by approximately 750,000 B/D (40 Mtoe), and natural gas by approximately 170 bcm (150 Mtoe: about half of the LNG traded in the world at present).

Results of major calculations (China and India)

● China

Economic growth in China will be driven by domestic consumption, shifting away from investment and exports. The annual economic growth rate is assumed to be 5.7%. Primary energy consumption will increase at an annual rate of 2.4% from 2.22 Btoe in 2010 to 3.99 Btoe in 2035, accounting for 23% of the global primary energy consumption. Energy consumption in China in 2035 is estimated to be approximately nine times that in Japan, while CO₂ emissions are estimated to be 10 times that in Japan, putting China top in both fields.

Oil: Demand for oil will expand from 8.8 million B/D in 2010 to 17.4 million B/D in 2035 due to rapid progress of motorization. As this cannot be met by domestic oil production, China’s dependence on oil imports will rise from 53% in 2010 to 76% in 2035.

Coal: Demand for coal will increase mainly for power generation, rising from 1.6 Btoe in 2010 to 2.21 Btoe in 2035. Although coal’s share in the primary energy will drop from the current 72% to 55%, it will remain the largest energy source in China. Steel production will reach a peak in the near future, rising from 640 million tons in 2010, and will then decline to just under 500 million tons by 2035. As a result, industrial consumption of coal will gradually decline.

Nuclear energy: At present, 30 nuclear units are under construction in China and a number of other reactor construction projects are at the planning stage. The installed capacity of nuclear power generation facilities in China in 2020 is projected to be 59 GW, then rapidly expanding to 111 GW in 2035. The share of nuclear energy in the electricity output will grow to 9.2% in 2035.

Advanced Technology Scenario: The introduction of advanced technologies will help achieve energy savings of 800 Mtoe (down 20%) compared to the Reference Scenario in 2035. On the other hand, CO₂ emissions in China will reach a peak in the 2020s through energy saving efforts and the growing use of non-fossil fuel energy sources such as nuclear power. As a result, CO₂ emissions will be reduced by 4.2 Gt (down 37%) by 2035 in comparison with the Reference Scenario.

● India

India’s economy will grow at an annual rate of 6.5% as its labor population increases. Primary energy consumption will increase at an annual rate of 3.9%, which exceeds the rate in China, increasing by 260% from 520 Mtoe in 2010 to 1,380 Mtoe in 2035.

Oil: Although the demand for oil will increase from 3.3 million B/D in 2010 to 7.9 million B/D in 2035, significant growth in oil production is not expected in India. Therefore, its dependency on oil imports will rise from 74% in 2010 to 87% in 2035.

Natural gas: The demand for natural gas is growing remarkably at an annual rate of 4.6%, and will expand from 50 Mtoe in 2010 to 160 Mtoe in 2035.

Coal: The demand for coal is growing at an annual rate of 3.7% mainly for power generation, and

will expand by 150% from 290 Mtoe in 2010 to 720 Mtoe in 2035. Coal remains the largest energy supply source (52%) in India. As the country's dependency on coal imports is forecast to increase, and the demand for coal is also increasing in other Asian countries, it is essential to secure sources.

Nuclear energy: India is introducing large-scale LWR technology from other countries in addition to its existing R&D program on the thorium cycle (PHWR). The installed capacity of power generation will grow from the current 4 GW to 18 GW in 2020, and to 38 GW in 2035. In parallel with this growth, the nuclear share in the total electricity output will rise to as high as 6.2% in 2035.

Advanced Technology Scenario: Energy conservation of 290 Mtoe (reduction of 21%) in comparison with the Reference Scenario can be achieved in 2035 by greater use of advanced energy saving technologies.

Results of major calculations (Projection of the world energy supply and demand through 2050)

The impacts of increased use of clean technologies on the world energy supply and demand and on the reduction of greenhouse gas emissions towards 2050 were analyzed as an extension of the projections made for the period until 2035.

Fossil fuel: The growth of fossil fuel consumption in the world will gradually slow down in the Advanced Technology Scenario. However, even in this scenario, fossil fuel will continue to account for 71% of global primary energy consumption in 2050. Therefore, it is important to efficiently utilize fossil fuel and secure stable supplies.

Natural gas: The global consumption of natural gas will continue to expand towards 2050 in both the Reference Scenario and the Advanced Technology Scenario. Therefore, it is essential to secure stable supplies of natural gas through continuous investment.

Power generation mix: The share of non-fossil fuel power sources (nuclear and renewable power generation) in the world electricity output in 2050 is approximately 30% (33%) in the Reference Scenario. This ratio is 60% in the Advanced Technology Scenario, consisting of approximately 80% (77%) in OECD countries and approximately half (49%) in non-OECD countries. Especially in the Advanced Technology Scenario, there will be a significant increase in the introduction of renewable energy. The installed capacity of wind power generation in the world in 2050 will be 13 times that at present, while that of photovoltaic power generation will be 58 times, that of concentrated solar power (CSP) 620 times, and that of biomass power generation 4 times compared to the current level.

CO₂ emissions: The reduction of energy-related global CO₂ emissions in 2050 in the Advanced Technology Scenario will remain at 22% from the 2005 level (almost the same level as 1990). The reduction in the "Low Nuclear Scenario" will be 13% in comparison with the 2005 level (12% increase from the 1990 level). It is necessary to develop and diffuse new innovative technologies beyond those assumed in this analysis in order to halve global CO₂ emissions by 2050. Specifically, it is essential to invest more heavily in RD&D for advanced technologies, such as renewable energy, safer nuclear power plants, CCS and other energy saving technologies to realize innovative breakthroughs and diffusion.

Position of this report

This outlook represents estimates based on theoretical and numerical integrity under certain assumptions. Given various uncertainties, estimated figures are expected to change considerably. We would be pleased if this work serves as a reference or basis for forecasting future energy supply and demand.