The 417th Forum on Research Works, 22 October 2014

The Institute of Energy Economics, Japan (IEEJ)

Asia / World Energy Outlook 2014

— *Analysis of low-growth scenarios for China and India and the climate change issue* —

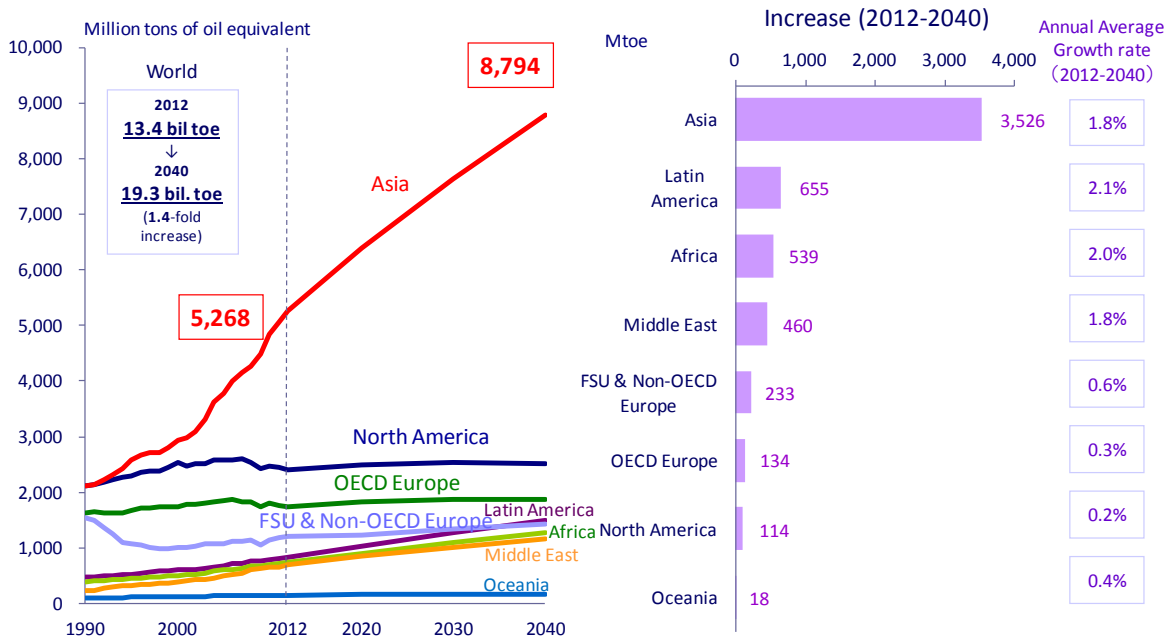
Summary

1. Energy demand and supply outlook up to 2040

Global energy consumption grows by 1.4 times during the next 28 years. Asia becomes the centre of the growth.

- In the *Reference Scenario*, in which energy supply and demand situations are expected to continue their present trends, world primary energy consumption increases 1.4 times from 13,371 million tons of oil equivalent (Mtoe) in 2012 to 19,276 Mtoe by the year 2040. Asia accounts for the largest share (60%) of the increase in consumption. Fossil fuel (oil, coal and natural gas) accounts for 70% of the increase in primary energy consumption. The world will continue to be heavily dependent on fossil fuels, even in the future.
- Consumption in Asia will reach 3,526 Mtoe by 2040, representing 60% of the world's increase. The increase for China and India alone represents 74% of the Asian increase and 46% of the entire world's increase. The combined increase of these two countries leads the world's demand increase.
- Oil consumption was 88.6 million barrels per day (Mb/d) in 2012. By mid-2020s, consumption will exceed 100 Mb/d, reaching 116.5 Mb/d in 2040. The overall increase of 27.9 Mb/d is equivalent to more than 90% of the current OPEC crude oil production. In order to meet such demand increase, expansion of supply including the development of conventional and non-conventional resources remains a challenge.
- Natural gas production and consumption will increase faster than any other forms of energy. By 2040, it will replace coal as the second most important source of energy, second only to oil. Natural gas demand will increase 1.7 times between 2012 and 2040, increasing from 3.44 trillion cubic metres (Tcm) to 5.88 Tcm. Demand for liquefied natural gas (LNG) will more than double during the same period, increasing from 237 million tons (0.32 Tcm) to 548 Mt (0.74 Tcm).

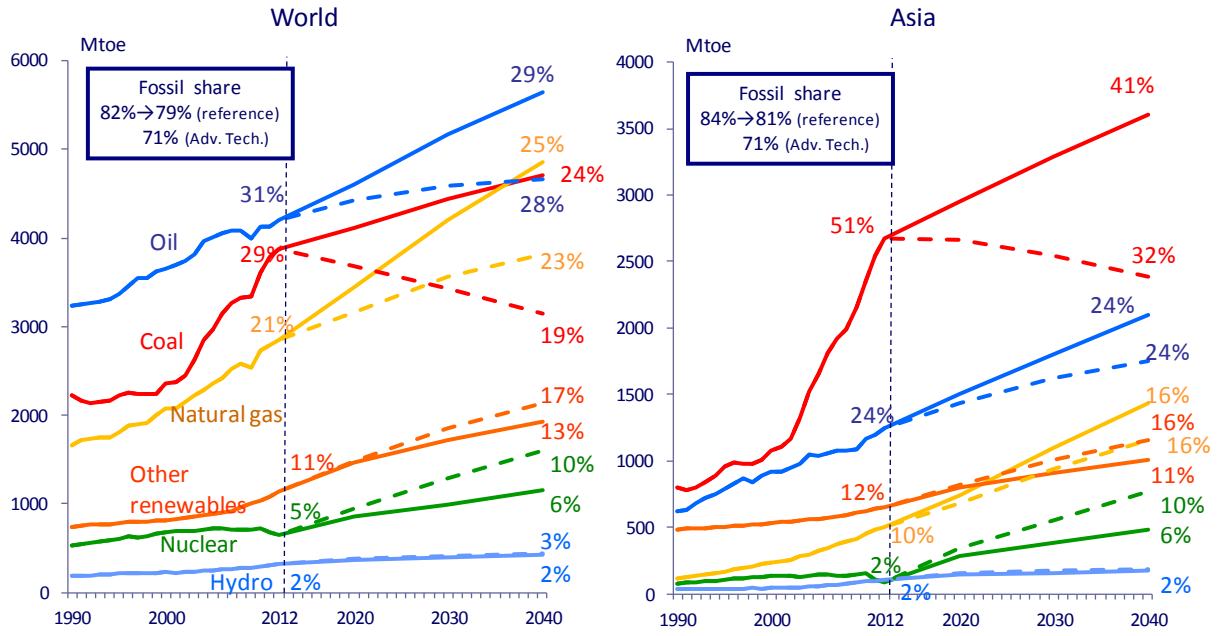
Figure 1 World primary energy consumption (by region)



- In order to meet such increase in demand for oil and natural gas, additional exploration for conventional resources and the development of unconventional resources, such as shale oil and gas, is very important. The *Enhanced Development Scenario* in this study assumes significant progress in the development of unconventional resources worldwide. In that analysis, total unconventional crude oil production would reach 25 Mb/d by 2040, compared to 6 Mb/d in the Reference Scenario. For natural gas, the production reaches 2.7 Tcm instead of 1.6 Tcm in the Reference Scenario. Such increases would relax any tensions between the supply and demand of international oil and natural gas markets and would lower prices. It would lower demand for Middle East oil in terms of international trade[1].
- Coal consumption increases to 6,722 million ton of coal equivalent (Mtce, 1 Mtce = 0.7 Mtoe) in the Reference Scenario by 2040 from in 2012 5,541 Mtce, increasing 1.2 times. Most of the increment will be steam coal for power generation and others. In China, coking coal for steel production is expected to peak out before 2040.

[1] Refer to "*Asia/World Energy Outlook 2013*" in http://eneken.ieej.or.jp/en/whatsnew/413.html for more information.

Figure 2 Primary energy consumption (World and Asia: by energy source)



Solid lines: Reference Scenario
Dashed lines: Advanced Technologies Scenario
The percentages represent the shares in total global/Asian primary consumption

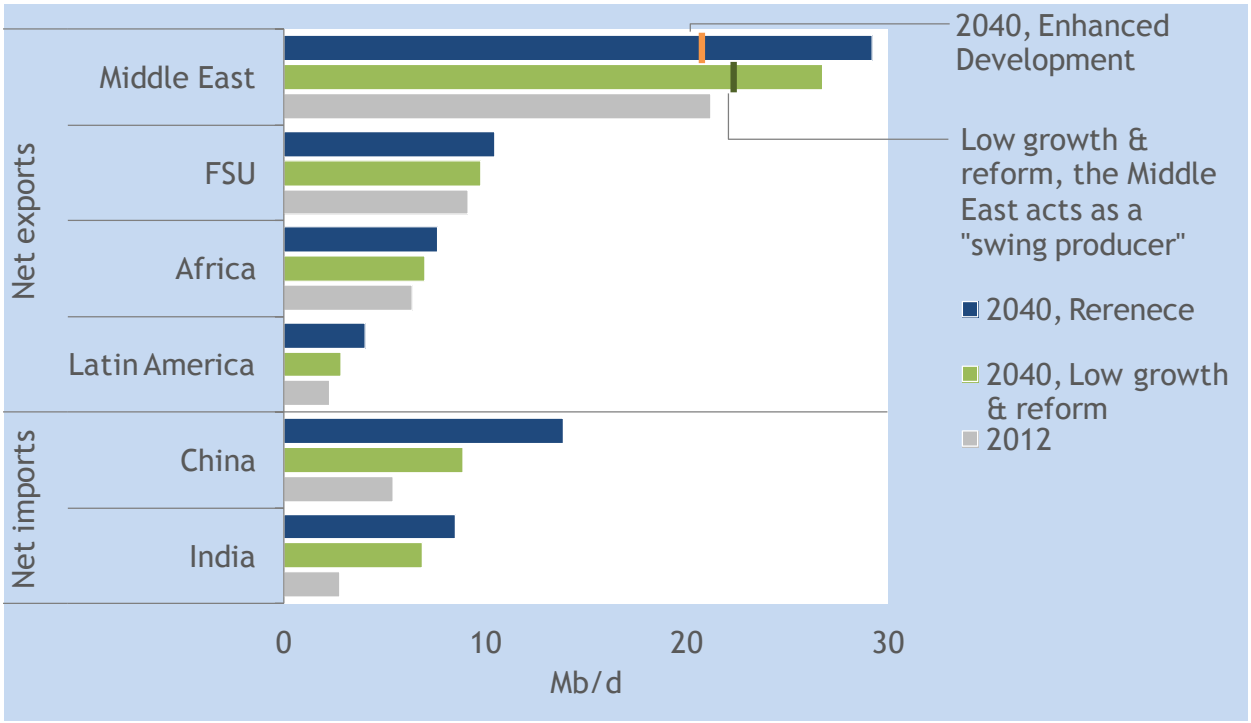
- Wind and solar photovoltaic (PV) power generation capacity will expand between now and 2040 by 3.5 times and by 6.4 times, respectively. Capacities for wind would reach 996 GW and solar PV would be 622 GW. Wind and solar PV power generation would reach 2,482 TWh by 2040 and represent 6% of total electricity generation. The generation from renewable energy including biomass, waste and geothermal power plants would reach 10% of the total electricity generation, and renewable power generation including hydro reaches 22%.
- World nuclear power installed capacity will expand to 618 GW in 2040 from 389 GW in 2013. The amount of generation by 2040 is 4,451 TWh (11% of the total amount of generation). The centre of the expansion of non-fossil energy generation comes from Asian emerging markets, including China and India.
- By 2040, the *Advanced Technologies Scenario* expects that the maximum deployment of energy efficiency and low-carbon technologies would reduce world primary energy consumption by 15%, and reduce Asia's consumption by 16%, to 16,374 Mtoe and 7,398 Mtoe, respectively. Significant reduction in coal consumption, especially in the power generation sector is anticipated.

2. Impact of low economic growth in China and India

Slower GDP growth in China and India would reduce demand and lower oil and gas exports from the Middle East and the former Soviet Union.

- While Chinese economy continues to grow, the financial risk and other banking issues, the housing and asset bubble problems, the deterioration of the environment, etc. also increase. Such situation whispers, for the first time, that a low-growth scenario would be appropriate. In India, as suggested by Prime Minister Narendra Damodardas Modi, the economy is expected to grow rapidly. However, reform policies are not easy to introduce and the success or failure of those policies is not yet clear, also suggesting a low growth scenario.
- The Reference Scenario assumes average annual real GDP growth rate until 2040, of 5.4% for China and 6.2% for India. The *Low Growth Scenario* assumed in this analysis is 3.9% and 5.3% for China and for India, respectively. This Outlook also analyses the impact on energy supply and demand assuming that China and India introduce structural reforms and move forward towards energy efficiency improvement and low-carbon technologies (the *Low Growth and Reform Scenario*).
- In the Reference Scenario, China and India will increase energy consumption by more than the current total energy consumption for the United States and Japan (approximately 2,600 Mtoe) by 2040. That is an enormous increase. The Low Growth and Reform Scenario diminishes the growth in demand to 30% of the growth under the Reference Scenario. The largest decrease is with coal, but in terms of international energy supply and demand, the impact on oil and natural gas is of larger significance.
- The export region that would suffer the biggest impact by the decrease in consumption of oil in China and India would be the Middle East. In the Low Growth and Reform Scenario, the incremental net exports from the Middle East are 31% lower than the Reference Scenario by the year 2040 (equivalent to 2.5 Mb/d). The exports from Latin America and the former Soviet Union would also be heavily compressed. The Middle East would lose as much as 6.9 Mb/d if the region plays as a swing producer and exports from other regions of the world do not change. By 2040, natural gas net import into China will be lower than in the Reference Scenario by 45%, and imports into India would be lower by 38%. The former Soviet Union and the Middle East would be the most affected by the lower demand.
- If Russia's relations with Western countries worsen while they are strengthen with China, the impact of low growth will be larger. With the Low Growth and Reform Scenario, the former Soviet Union and the Middle East would lose 30 percent of the anticipated increase in net exports.

Figure 3 Crude oil net exports/imports in 2040
(Reference Scenario and Low Growth and Reform Scenario)



"Reform" is the key under low economic growth. Low growth and reform is beneficial to energy security and global/local environment.

- The unintended slow growth could lead to a further expansion of the gap between the poor and the rich, to environmental deterioration and the stagnation in energy-saving technology developments. China's reform of its economic structure from an investment and exports-driven economy to a consumption-driven economy follows a path of development quite different from the past economic growth-oriented principles. Under the same low-growth rate assumptions, India's future will also be different if it seeks the reform of its energy structure and commitment to a low carbon future. For both countries, it is one of the desirable pictures of the future society to achieve a strong economic structure and secure employment through reforms, promoting energy-savings and low-carbon technologies.
- Low economic growth and reforms would reduce the increase in energy import dependency of China and India, and contribute to their energy security. This scenario also contributes advantageously to the global and local environmental issues, relative to the Reference Scenario. By 2040, carbon dioxide (CO_2) emissions under the Low Growth

Scenario are reduced by 3.2 Gt, from the Reference Scenario, and are reduced additionally by 4.2 Gt under the Low Growth and Reform Scenario.

- Reduced energy exports from the Middle East and the former Soviet Union would be most subject to the downside risks of a drop in GDP. On the other hand, the Low Growth and Reform Scenario would relax the international energy market supply and demand, reducing the overall greenhouse gas (GHG) emissions. A relaxed supply and demand could reduce energy prices to the benefit of energy consuming countries.

Figure 4 Energy related CO_2 emissions in 2040
(Reference Scenario, Low Growth Scenario and Low Growth and Reform Scenario)

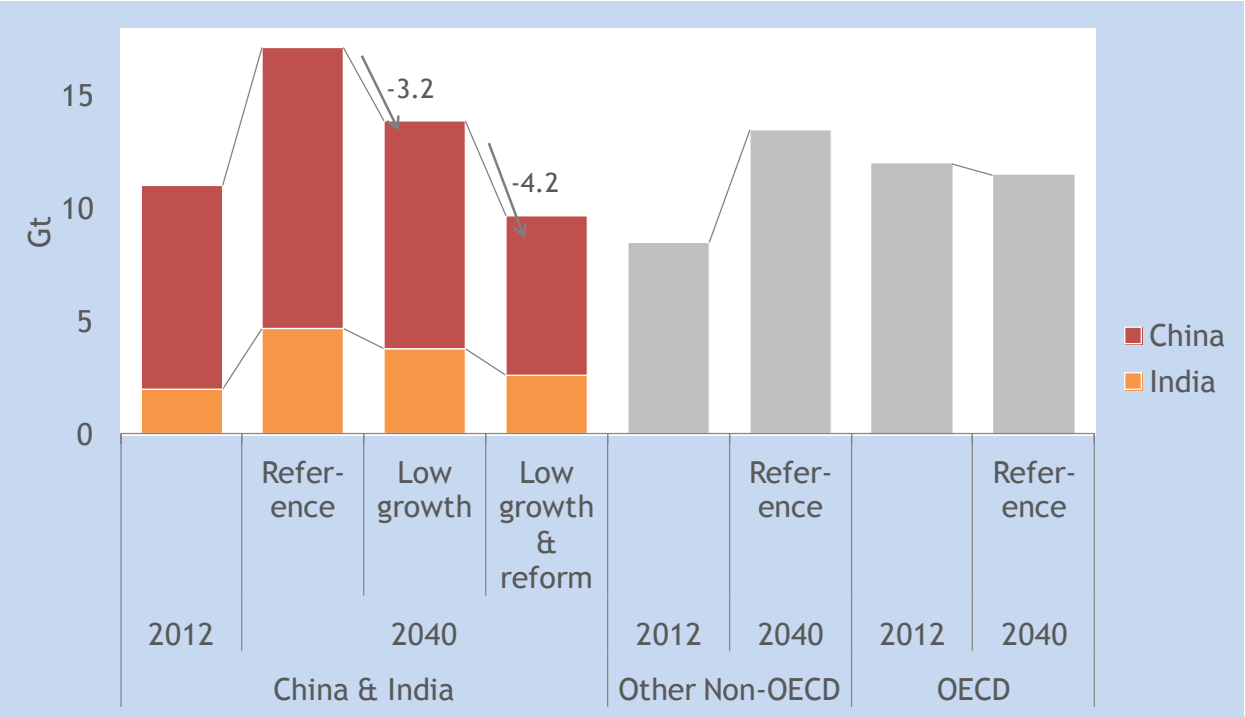
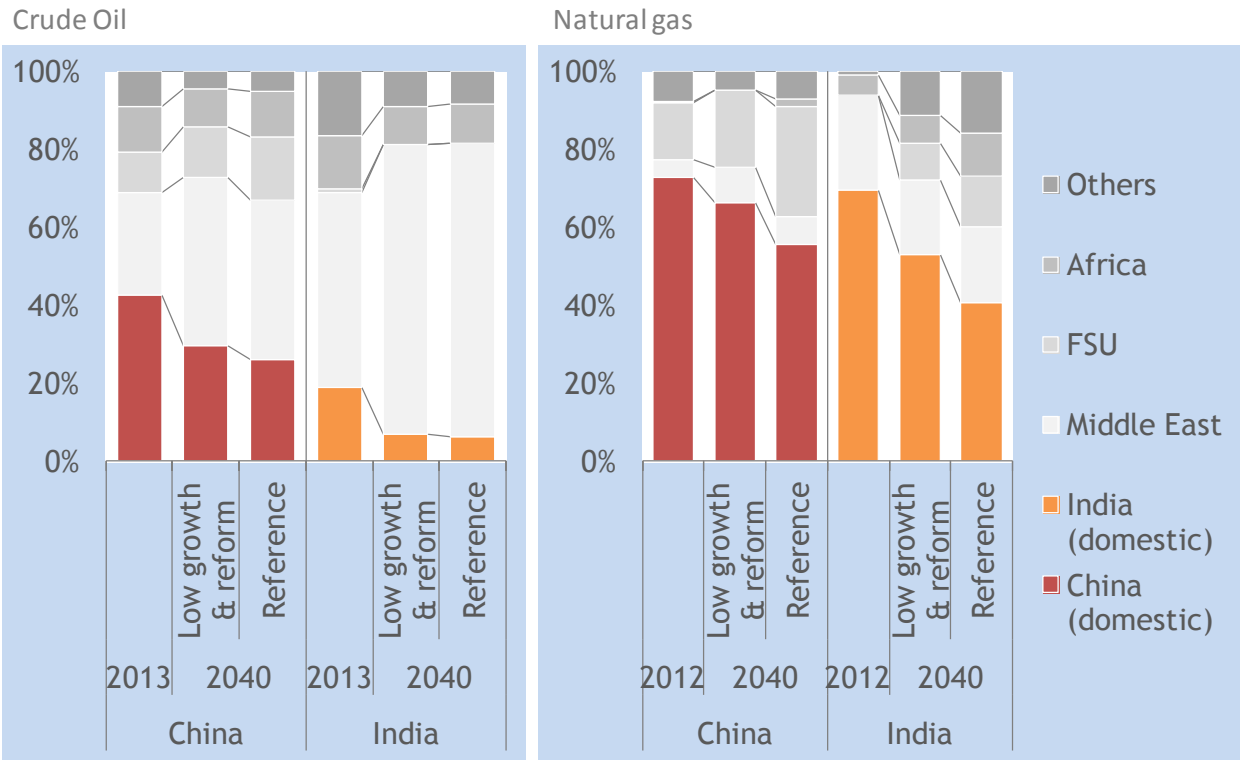


Figure 5 Crude oil and natural gas supply to China and India



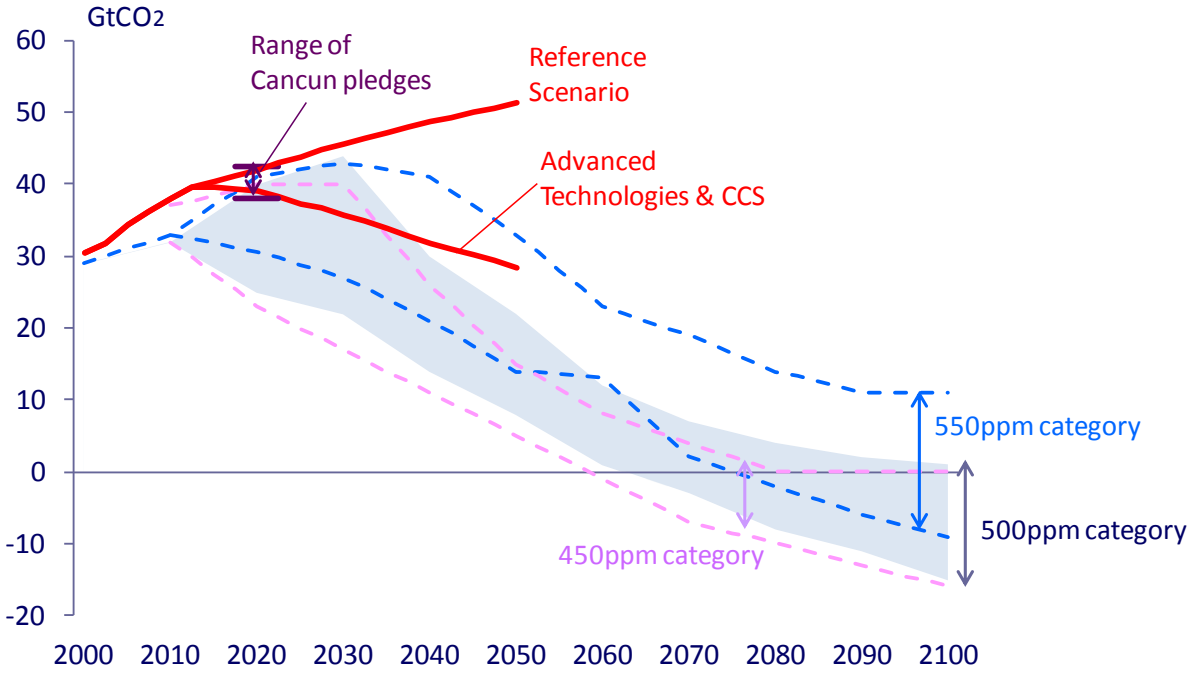
3. Addressing the climate change issues

The difficulties to meet the 450 ppm target

- In the Reference Scenario, world energy-related CO_2 emissions will reach 47.0 Gt by 2050, an increase of 44% from the current levels. The Advanced Technologies Scenario, which assumes the introduction of best energy, and low-carbon technologies combined with carbon capture and storage (CCS), lowers emissions sharply from the Reference Scenario. Emissions by 2050 would be 24.2 Gt, representing an increase of 14 percent above 1990 or a 26% reduction from 2012 levels. That is quite far from halving from the current levels.
- The scenarios in which GHG concentrations in the atmosphere be limited to 450 ppm in CO_2 equivalent are considered to achieve a less than 2°C temperature rise from pre-industrial level to 2100. To achieve such concentrations the wide spread and use of CCS with bioenergy (BECCS) ,tree-planting and other measures in the second half of this century would be required; those scenarios imply considerable uncertainty. It seems that meeting the 450 ppm target is very difficult, as the Advanced Technologies Scenario + CCS is far from cutting by 50% the global CO_2 emissions.

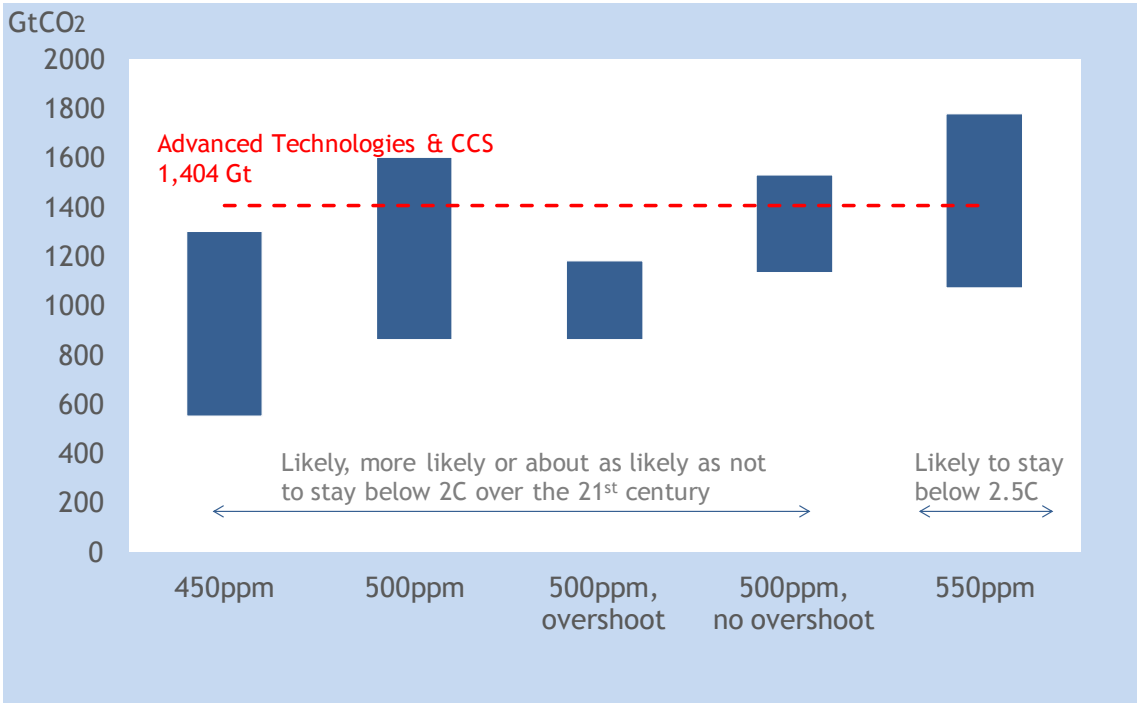
- The Intergovernmental Panel on Climate Change (IPCC) working group III contribution to the 5th Assessment Report, was published in April 2014. The report does not limit the possibility to meet the 2°C target only to the 450 ppm scenarios, with probability of more than 50% of achieving the target with the 500 ppm scenarios. With appropriate adaptation allowing up to 2.5°C, the rise could reach 550 ppm. The Advanced Technologies Scenario + CCS falls under the 550 ppm category with the comparison of CO_2 emission pathways, and under the 500 ppm category with the comparison of the cumulative CO_2 emissions (2011-2050).

Figure 6 Global CO_2 emissions pathways



Sources: IPCC, UNEP, The Emissions Gap Report 2013, etc.

Figure 7 Cumulative CO_2 emissions (2011-2050)



Source: IPCC AR5

Table 1 Categories in IPCC AR5-WG3

Category label GHG concentration in 2100 (CO_2-eq)	Subcategories	Change in GHG emissions from 2010 to 2050 (%)	Temperature change (relative to 1850-1990)	
			2100 Temperature change (℃)*	Likelyhood of staying below temerature level over the 21st century
450 (430-480)		-72～-41	1.5～1.7 (1.0～2.8)	66～100%
500 (480-530)	No overshoot of 530 ppm CO_2-eq	-57～-42	1.7～1.9 (1.2～2.0)	50～100%
	Overshoot of 530 ppm CO_2-eq	-55～-25	1.8～2.0 (1.2～3.3)	33～66%
550 (530-580)	No overshoot of 580 ppm CO_2-eq	-49～-19	2.0～2.2 (1.4～3.6)	0～50%
	Overshoot of 580 ppm CO_2-eq	-16～+7	2.1～2.3 (1.4～3.6)	0～50%
(580-650)		-38～+24	2.3～2.6 (1.5～4.2)	0～50%
(650-720)		-11～+17	2.6～2.9 (1.8～4.5)	0～33%
(720-1000)		+18～+54	3.1～3.7 (2.1～5.8)	0～33%
(1000-)		+52～+95	4.1～4.8 (2.8～7.8)	0～33%

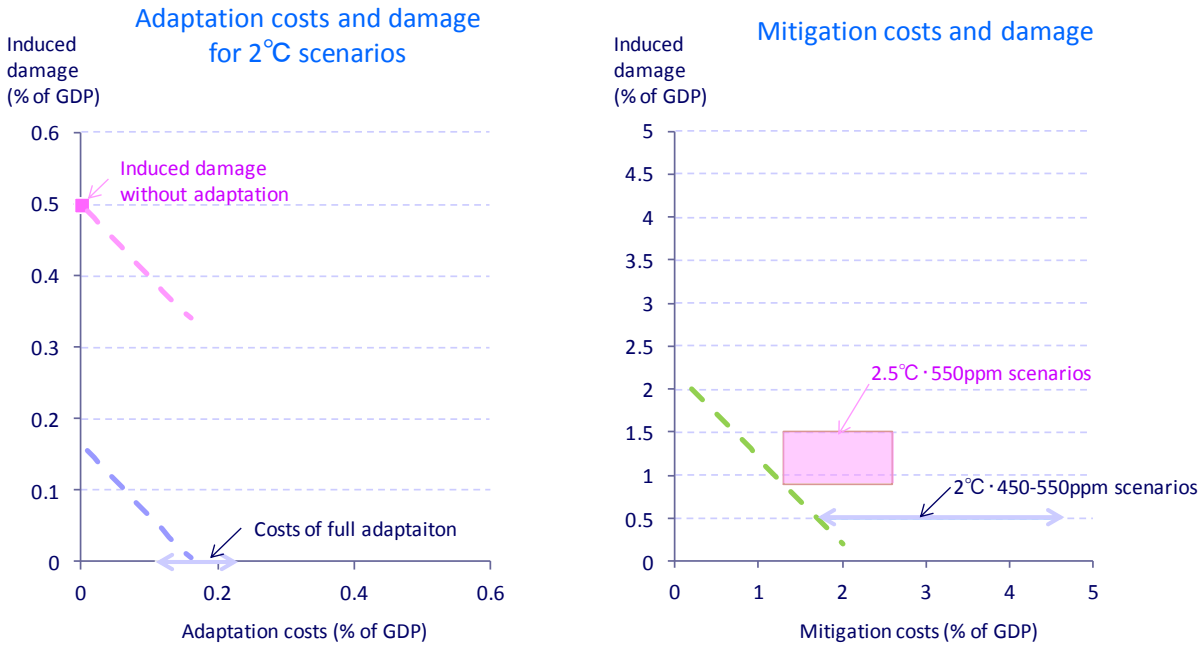
* The range of temperature change in the parentheses includes the carbon cycle and climate system uncertainties

Source: IPCC AR5

The need to consider various strategies, including 500 or 550 ppm targets and adaptation

- If we only pursue the 450 ppm scenarios, in which the achievement of bigger cuts than the Advanced Technologies Scenario are required, far more difficult coordination among the major economies in international negotiations would be expected. We must seek for practical measures and strategies in future international negotiations, keeping in mind not only the achievement of 450 ppm target, but also the retreating to 500 or 550 ppm targets. In addition, adaptation measures should also be considered, as well as the development of advanced technologies, including carbon capture and utilisation (CCU), and space solar power system, which would become very important from a longer perspective beyond 2050.
- We should not stick to the 450 ppm target as the only realistic solution, but take into account various options and strategies, considering the realistic limits to the CO_2 emissions reductions, costs of mitigation and adaptation, and the current situations of international negotiations.

Figure 8 Relation of mitigation and adaptation costs to the damage induced by climate change



Source: IPCC AR5

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