IEEJ Energy Outlook 2015

– Impact of lower oil price scenario and pragmatic approach to address climate change –

(Asia/World Energy Outlook 2015)

November 12, 2015

The Institute of Energy Economics, Japan (IEEJ)

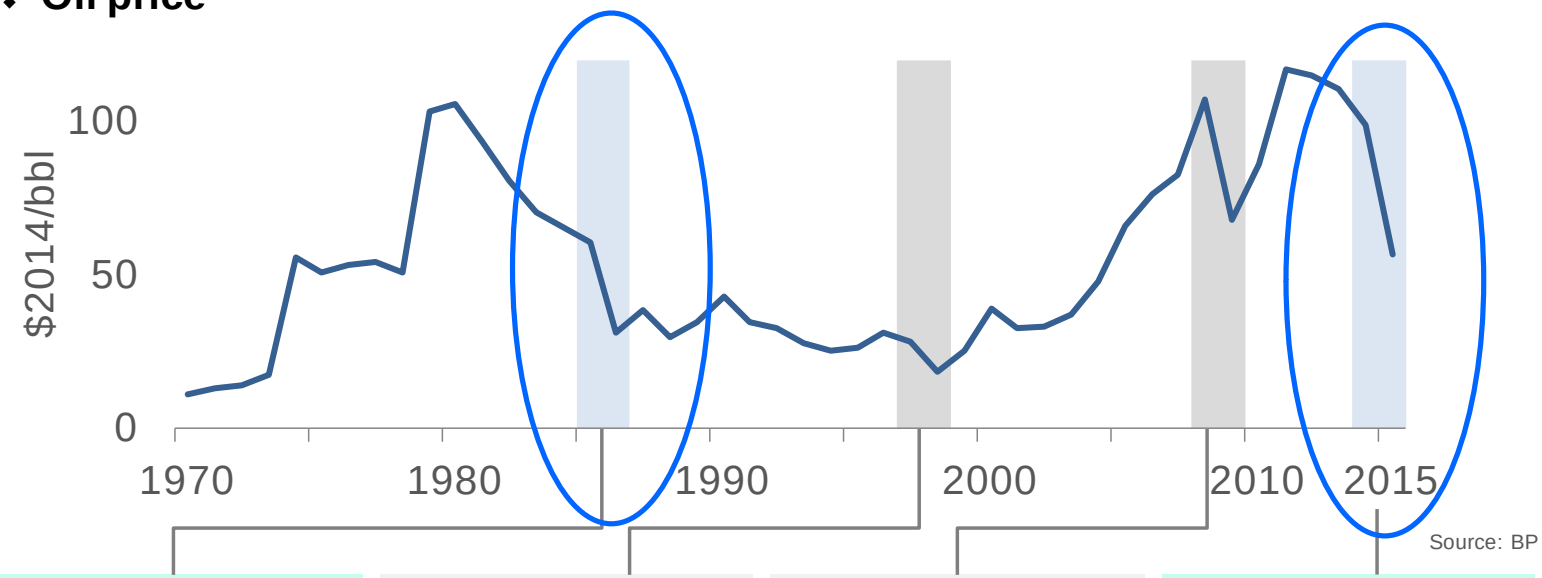
CEO & Chairman **Masakazu Toyoda**

Contents

“History doesn’t repeat itself, but it does rhyme”

Mark Twain

❖ **Oil price**



- Decreases in demand and increases in supply by non-OPEC following high price after the oil crises
- Severer competition in OPEC
- Easy supply-demand balance affected by the Netback pricing

- Decreases in emerging economies’ demand by the Asian financial crisis
- Expansion of OPEC production quota and excess production by the members over their quota

- Sharp drop of demand by the Lehman shock
- Expansion of production capacity by Saudi Arabia and others

- Increases in supply by non-OPEC and OPEC
- Slow growth of global demand

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Various factors involve oil price

❖ Factors related with oil price

Supply

- OPEC's policy
- Fiscal break-even price
- OPEC's spare capacity
- Increases in production of unconventional oil

Demand

- Economic growth
- Stock in developed countries
- Oil use policy in developing countries
- Car ownership and fuel economy

Expectation in market

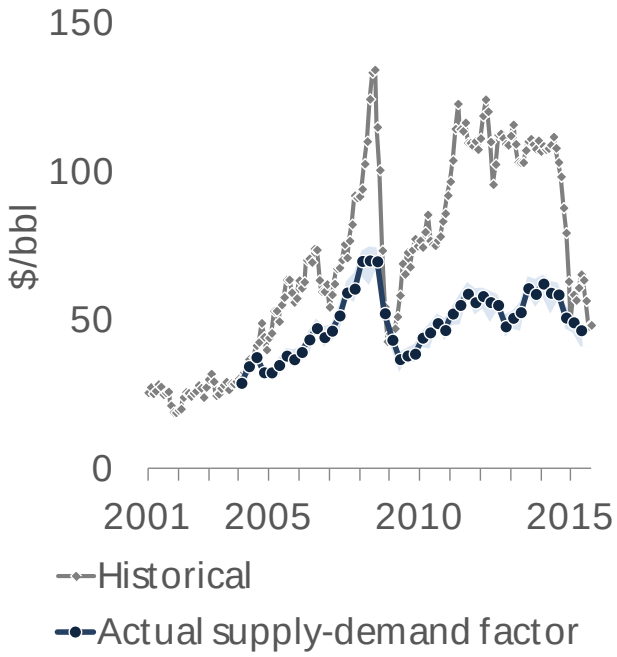
Money

- Stock prices and exchange rates
- Expected inflation
- Money supply
- Risk appetite
- New investment commodity and technology

Risk

- Political situation in producing countries
- Foreign policy
- Terror to related facilities
- Unusual weather, disaster and accident
- Strike, etc.

❖ Historical and actual supply-demand factor prices



Oil price is found by expectation in the futures market affected by supply and demand, risk and money.

Oil price was much higher than that was indicated by actual supply-demand factor.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Energy Outlook through 2040

IEEJ Energy Outlook 2015, Highlights

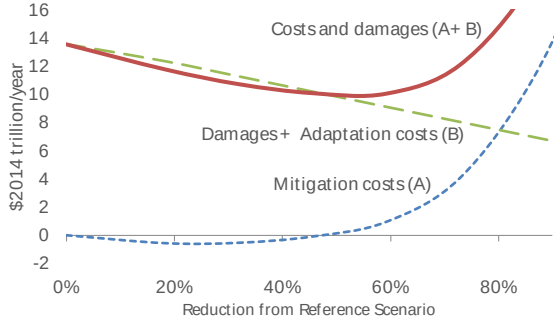
❖ Energy outlook and pragmatic measures against climate change

- Global energy demand continues to increase led by Asian emerging economies, etc.
- Huge effect is expected by energy conservation and mitigating climate change measures. The target halving CO_2 emissions by 2050, however, is hardly achieved.
- Mitigating measures expected from major emitters' INDCs fail very likely to reduce sufficiently GHG emissions.
- Balancing among mitigation, adaptation and damage and assessing various emission reduction trajectories with long-term view are essential.

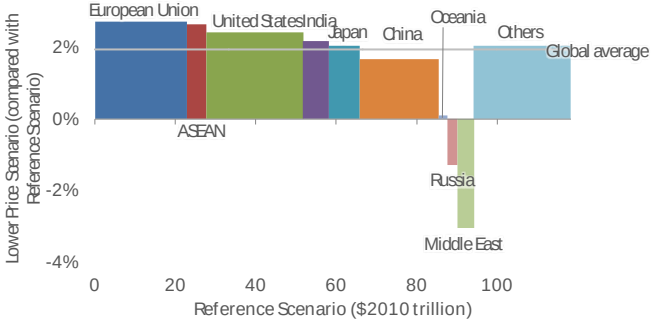
❖ Impact of lower prices by easy energy supply and demand balance

- Production of the Middle East grows by only 1.0 Mb/d if development of unconventional resources, strong energy conservation and decarbonisation progress coincidently.
- Whilst lower prices are a great boon to energy importing countries, exporters are inevitable to face damage unless they reform the current economic structure.
- There is risk of supply-demand imbalance in the future due to the absence of proper investment under extreme unstable prices.
- Dialogue and cooperation between producers and consumers and those among consumers play a important role.

❖ Mitigation and adaptation costs and damage [2100]



❖ Economic impact by lower prices [2030]



(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Scenarios

Reference Scenario

This scenario reflects past trends as well as energy and environment policies that have been introduced so far. This scenario does not reflect any aggressive policies for energy conservation or low-carbon measures.

Advanced Technologies Scenario

In this scenario, energy conservation and low-carbon technologies are promoted for maximum impacts, as each country is assumed to implement powerful policies to enhance energy security and address climate change issues.

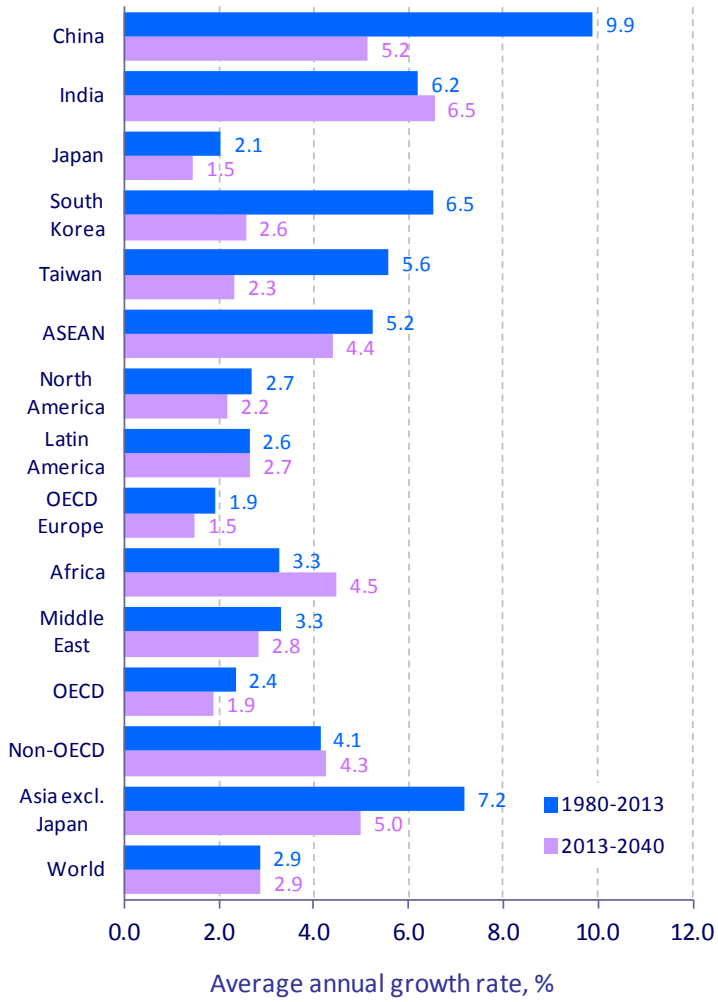
Lower Price Scenario

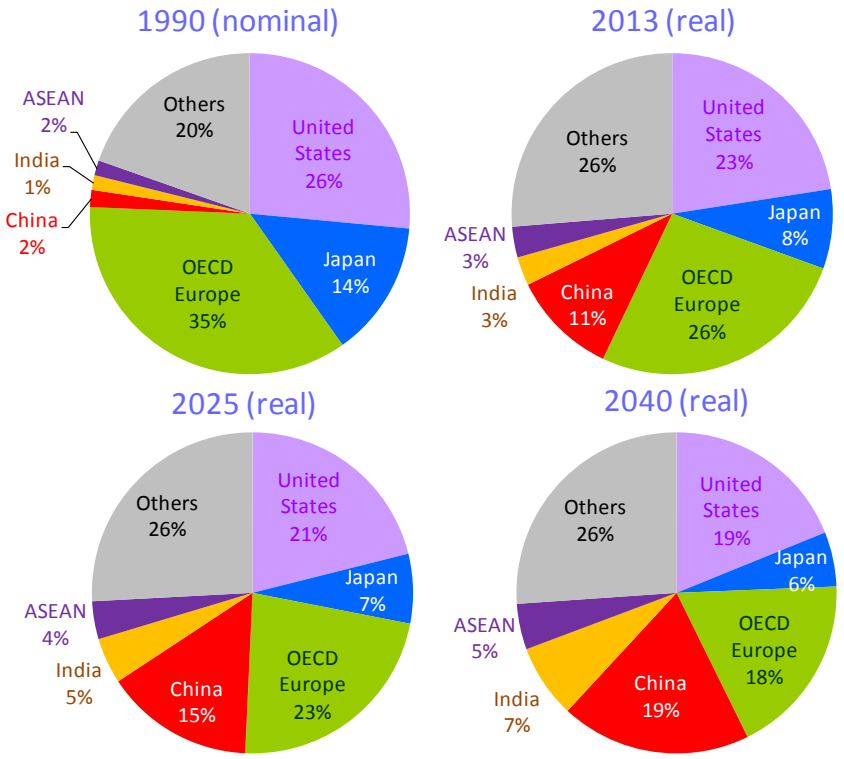
In this scenario, it is assumed that energy savings will be pursued as stringently as in the Advanced Technologies Scenario, while assuming large increases in unconventional oil and natural gas production, resulting in considerable relaxation of supply and demand.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Major Assumptions: Economic Growth

Note: Real values are in 2010 USD





- While the world economy is facing a variety of challenges, it is assumed to achieve a strong growth over the medium to long term.
- In the Reference Scenario, China's real GDP in 2040 is ahead of the United States and, is 3.5 times of Japan. India also overtakes Japan in the late 2030s, it is 1.4 times of Japan in 2040.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Major Assumptions: Primary Energy Prices

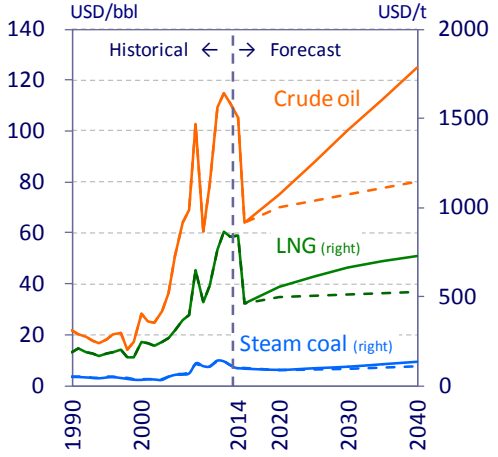
			Reference				Lower Price		
			2013	2020	2030	2040	2020	2030	2040
Crude oil	USD/bbl	Real	105	75	100	125	70	75	80
		Nominal	105	84	137	209	79	103	134
Natural gas	Japan	Real	842	554	663	730	498	507	528
	USD/t	Nominal	842	624	909	1,221	561	696	883
	Japan	Real	16.3	10.7	12.8	14.1	9.6	9.8	10.2
	USD/MBtu	Nominal	16.3	12.0	17.6	23.6	10.8	13.5	17.1
	Europe	Real	8.2	8.5	9.8	11.7	6.8	7.3	8.1
	USD/MBtu	Nominal	8.2	9.6	13.5	19.6	7.7	10.0	13.6
	USA	Real	4.4	4.5	5.6	6.8	3.4	3.7	3.9
	USD/MBtu	Nominal	4.4	5.1	7.7	11.4	3.8	5.1	6.5
Steam coal	USD/t	Real	98	89	106	132	86	96	108
		Nominal	98	100	145	221	97	132	181

- Prices are for calendar years. Real prices are in 2014 dollars.
- Japan's energy prices are on a CIF import basis.

- In the Reference Scenario, crude oil prices rises gradually again to $100/bbl by 2030 due to robust demand growth in non-OECD countries, emerging geopolitical risks and financial factors, oil supply constraints reflecting rising depletion rates for oil fields, etc. LNG prices will rise accordingly, with the existing price disparity shrinking due to expanding interregional trades.

- In the Lower Price Scenario energy prices remain lower due to the dull growth in demand in accordance with the diffusion of energy saving technologies, as well as further promotion of unconventional resources development.

CIF import prices for Japan

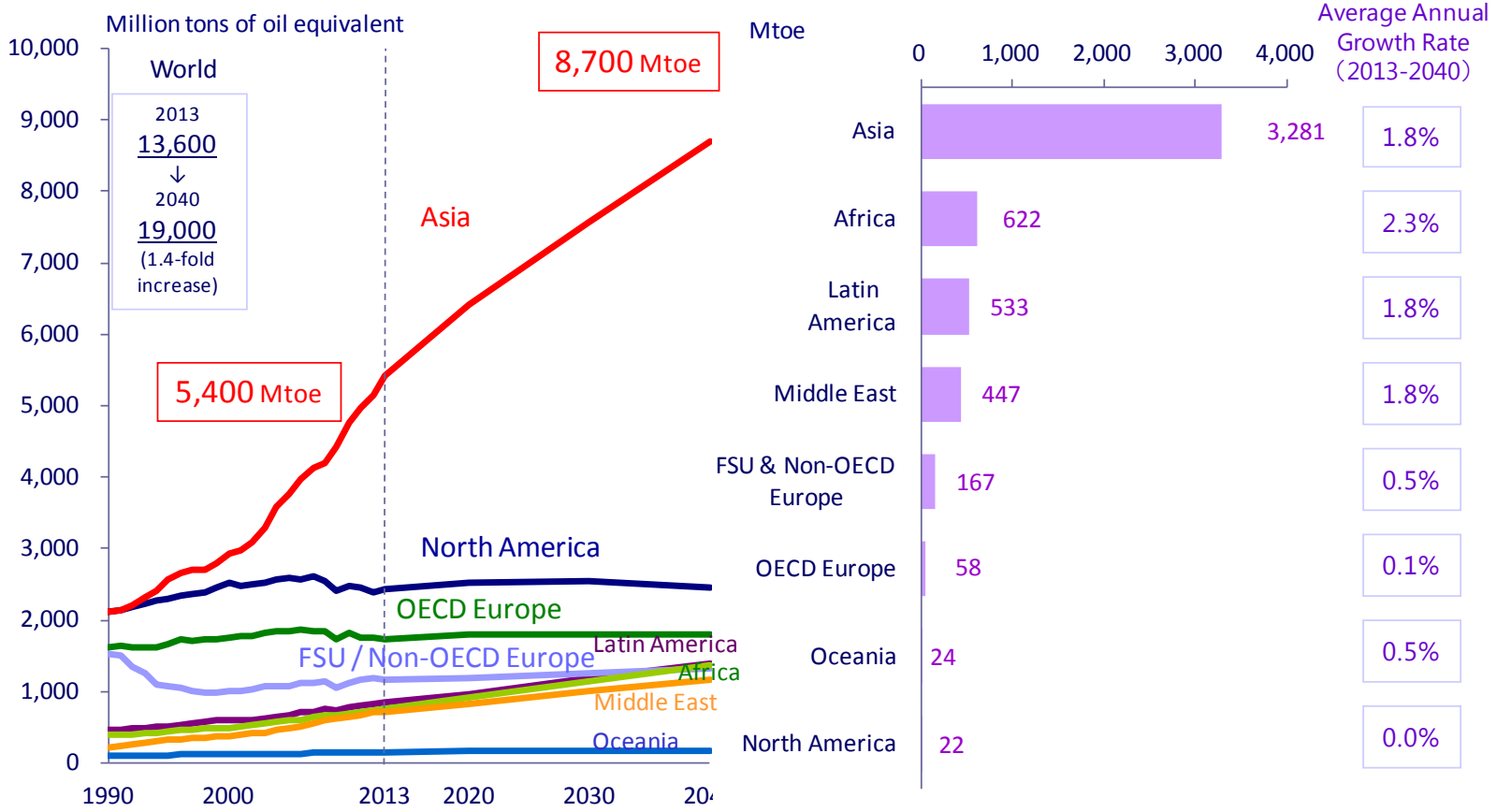


Solid line: Reference, Dashed line: Lower Price

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Primary Energy Demand by Region

Reference Scenario

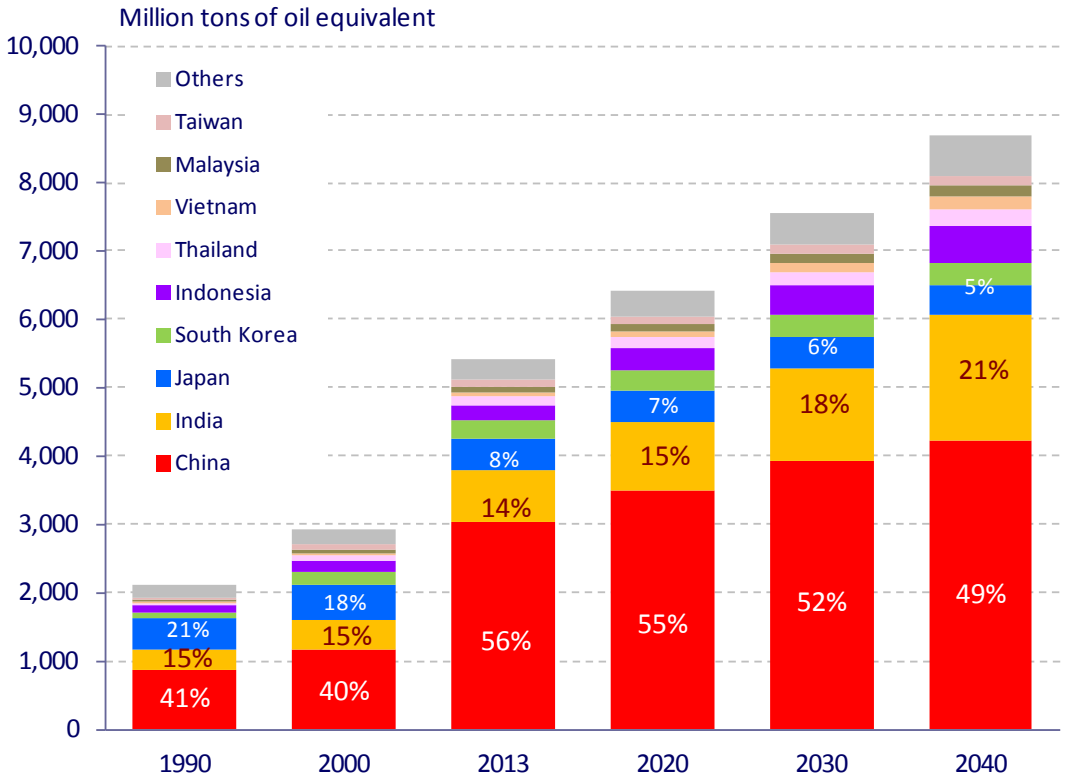


- Under steady economic growth assumption, Asian energy consumption in 2040 increases 1.6-fold from the present level (from 5.4billion tons in 2013 to 8.87billion tons in 2040).
- Non-OECD countries account for about 90% of global energy consumption increase between 2013 and 2040.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Primary Energy Demand (Asia)

Reference Scenario



Asia

2013
5,400
↓
2040
8,700
(1.6-fold increase)

China & India

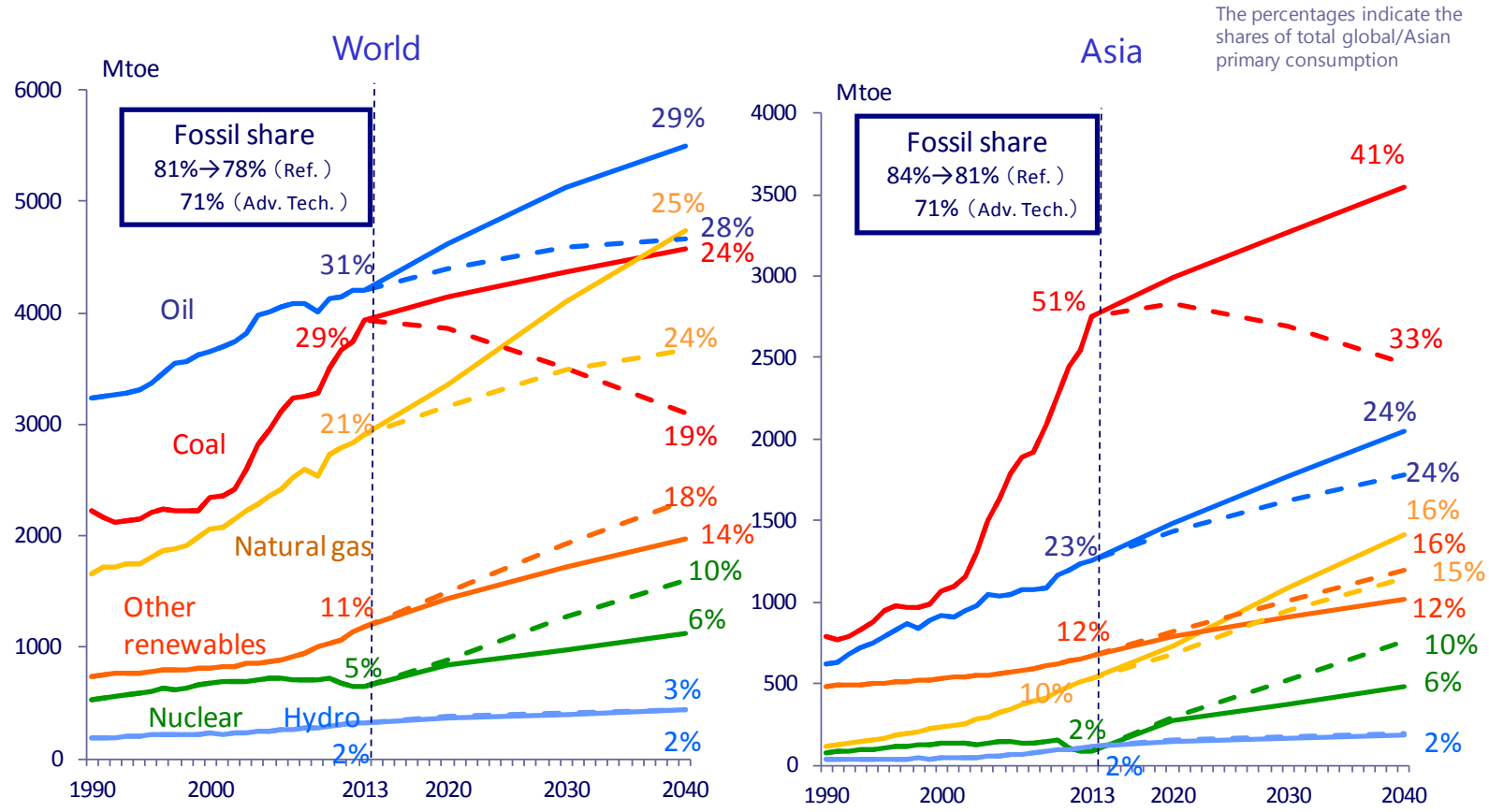
2013
3,000 780
↓
2040
4,200 1,800
(1.4-fold inc.) (2.3-fold inc.)

- Energy demand in China and India increase rapidly in line with economic growth. Their share of Asian energy demand expand 70% in 2040.
- Japan's energy consumption declines as a result of progresses in energy efficiency combined with a maturing economy and a decreasing population. Its share of Asian energy consumption shrinks from 8% to 5%.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Primary Energy Consumption by Source

Solid lines: Reference
Dashed lines: Adv. Tech.

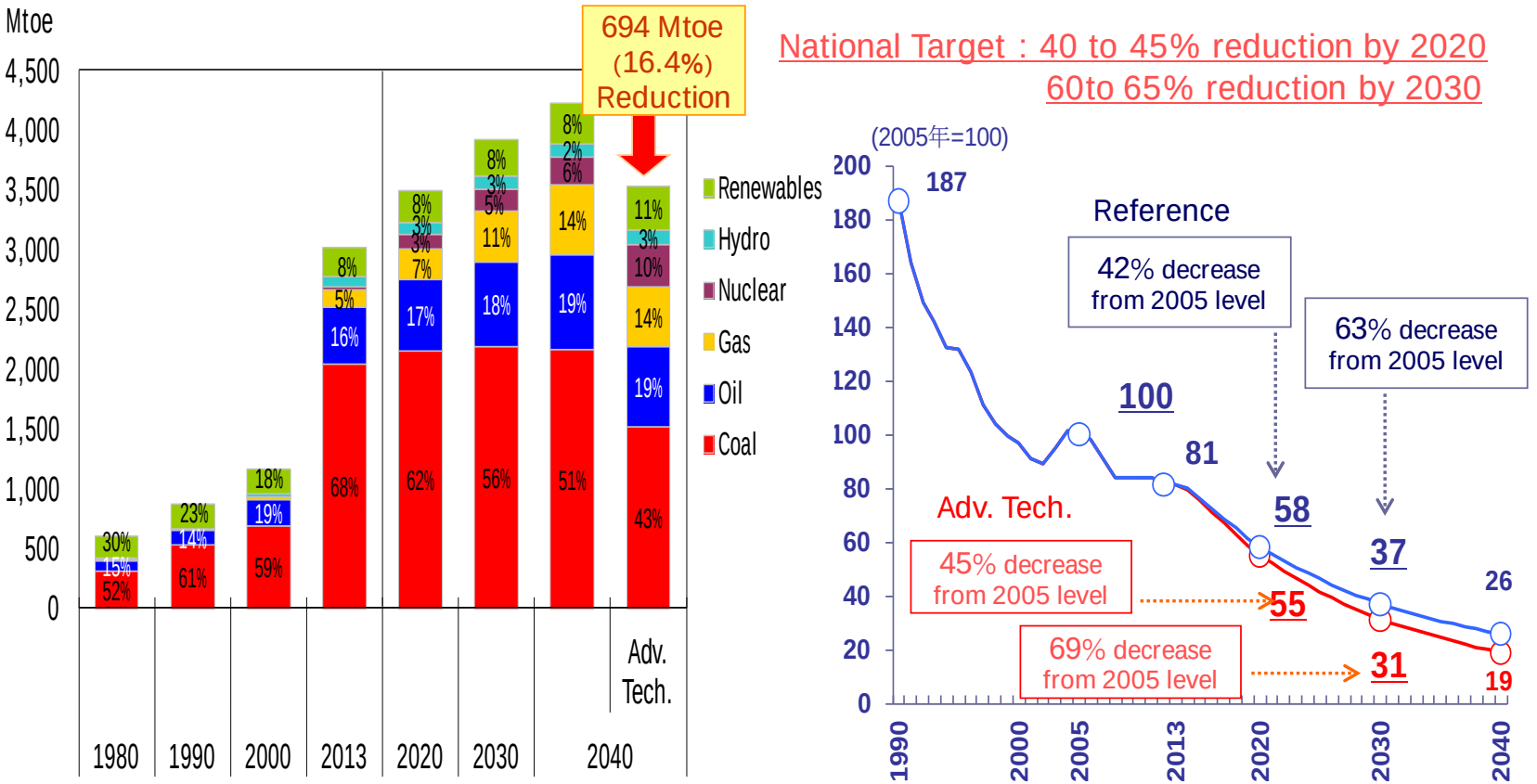


- In both the Reference and Advanced Technology Scenarios, oil continues to be the largest share of primary energy consumption and remains a major energy source up to 2040.
- In Asia, coal remains the largest share among energy sources. In the Advanced Technology Scenario, coal consumption declines substantially while retaining the largest share among energy sources.
- Share of fossil fuel declines until 2040, while maintaining the 70% in the Advanced Technology Scenario.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Primary Energy Demand in China

Reference
Adv. Tech.

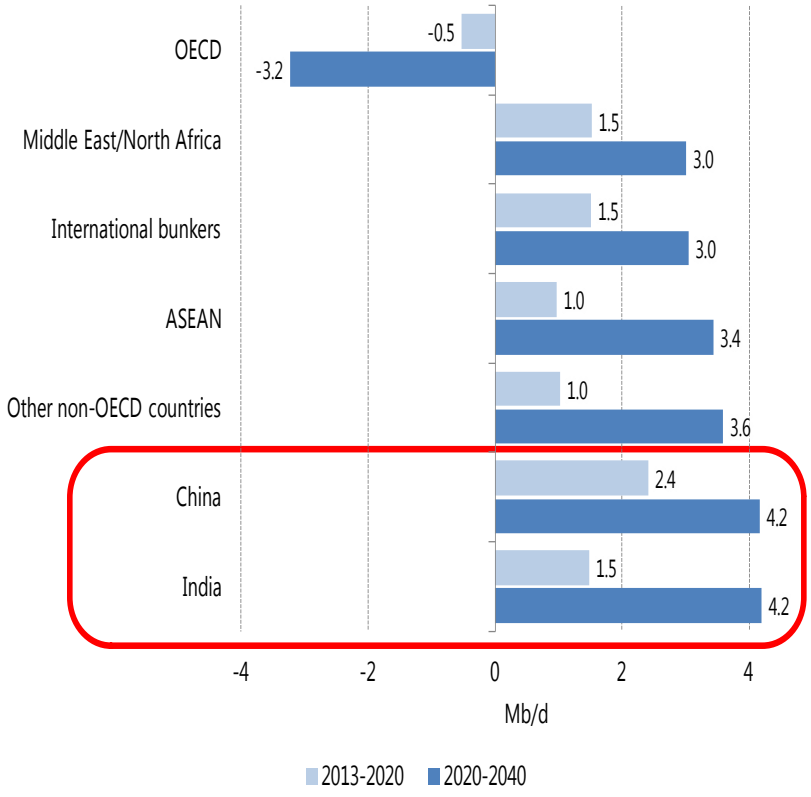


- TPED increases at an annual rate of 1.3% in the Reference Scenario at the back of robust economic growth. Oil expands reflecting rapid motorization.
- Natural gas increases sharply for household and commercial usage, especially in urban areas.
- In the Adv. Tech. Scenario, coal demand decreases, especially in power generation, TPED is 694Mtoe (16.4%) lower than that in the Reference Scenario in 2040.

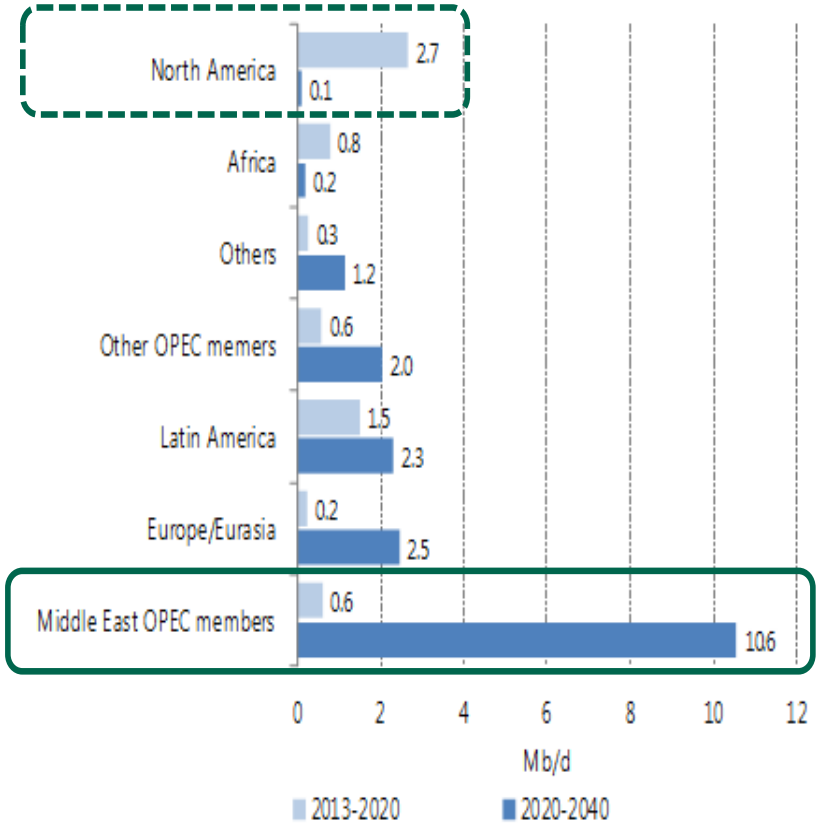
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Middle East OPEC will Return As Major Oil Suppliers

Oil Consumption Change



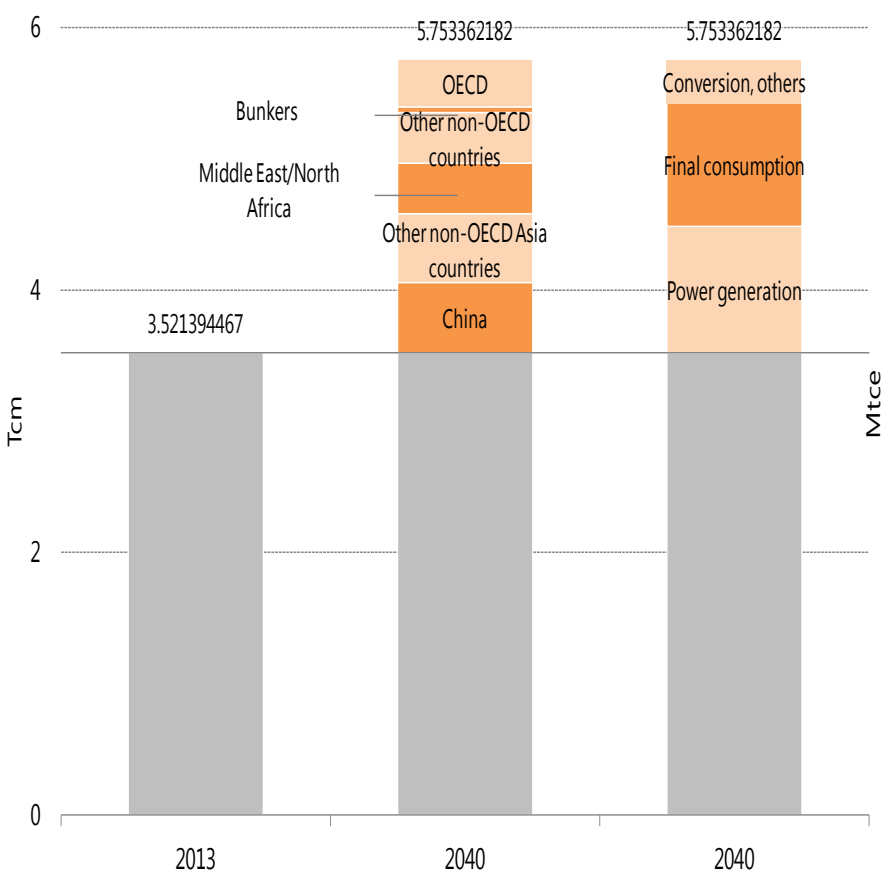
Crude Oil Supply Change



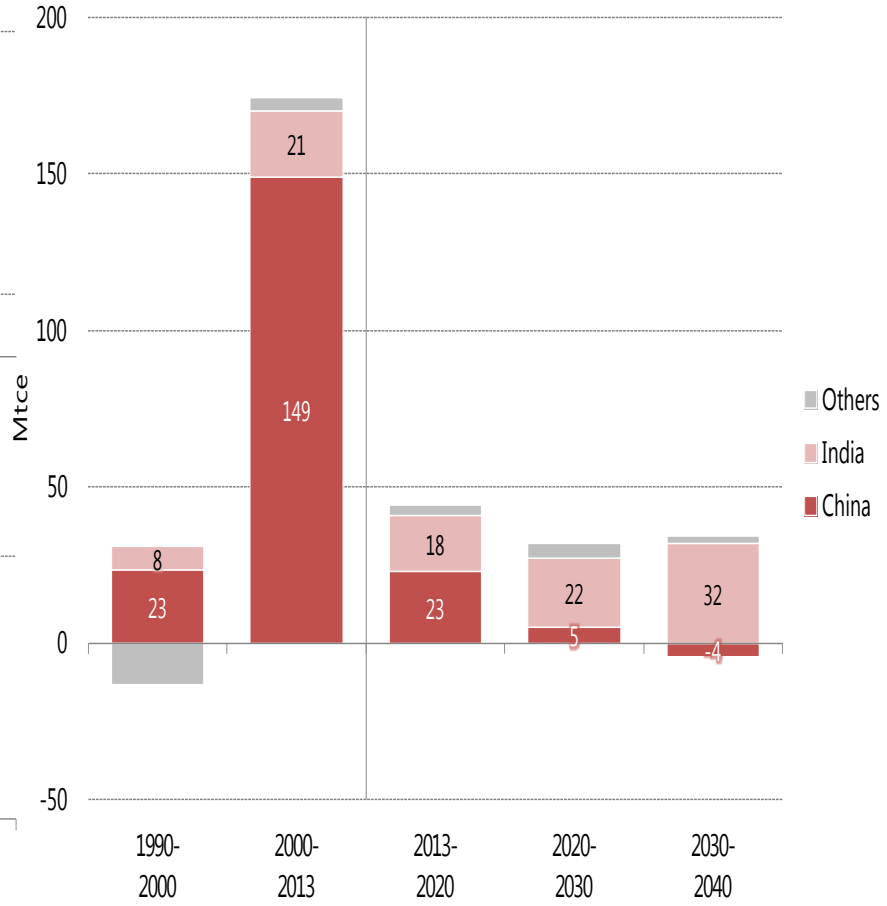
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Natural Gas Keeps Increasing while Coal Increases Less

Natural Gas Consumption



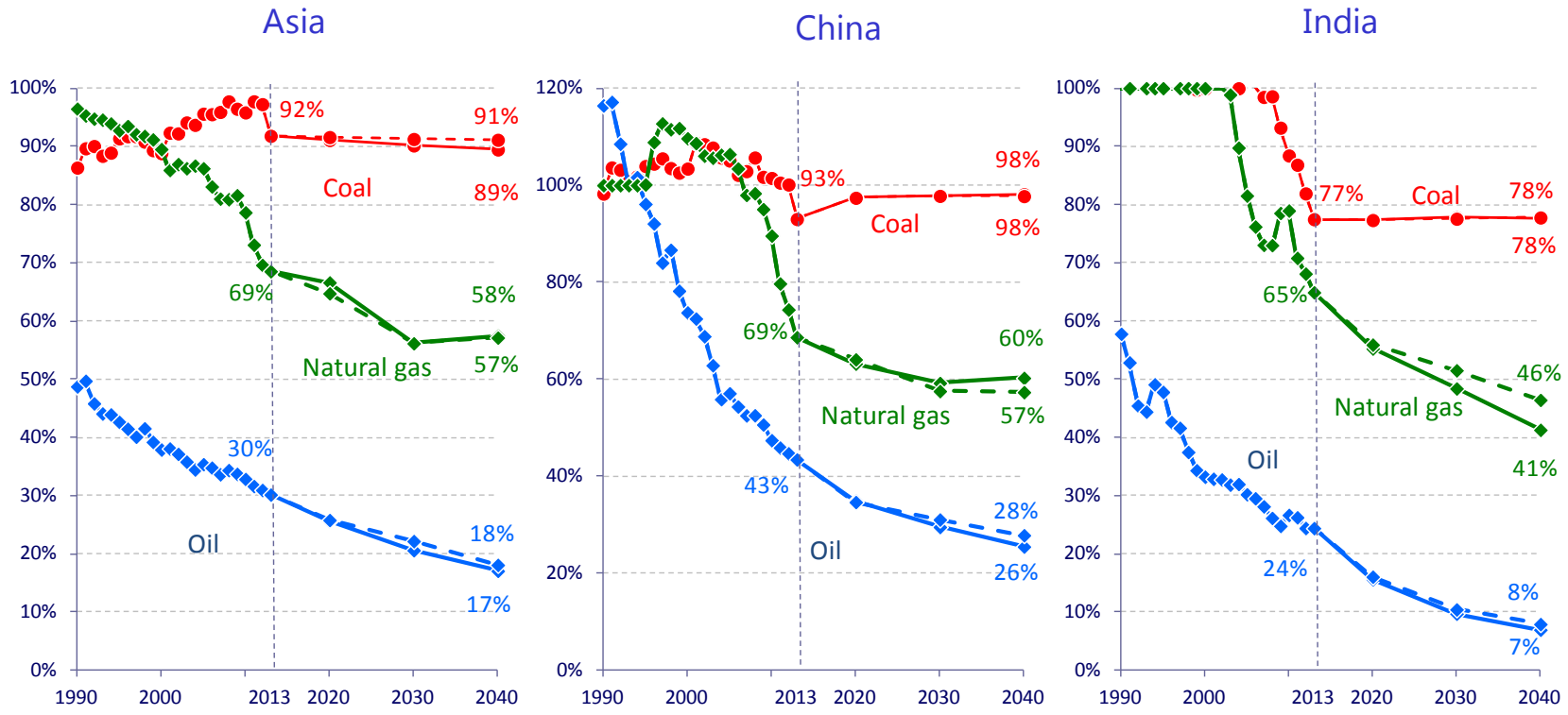
Coal Consumption Change



(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Energy self-sufficiency in Asia

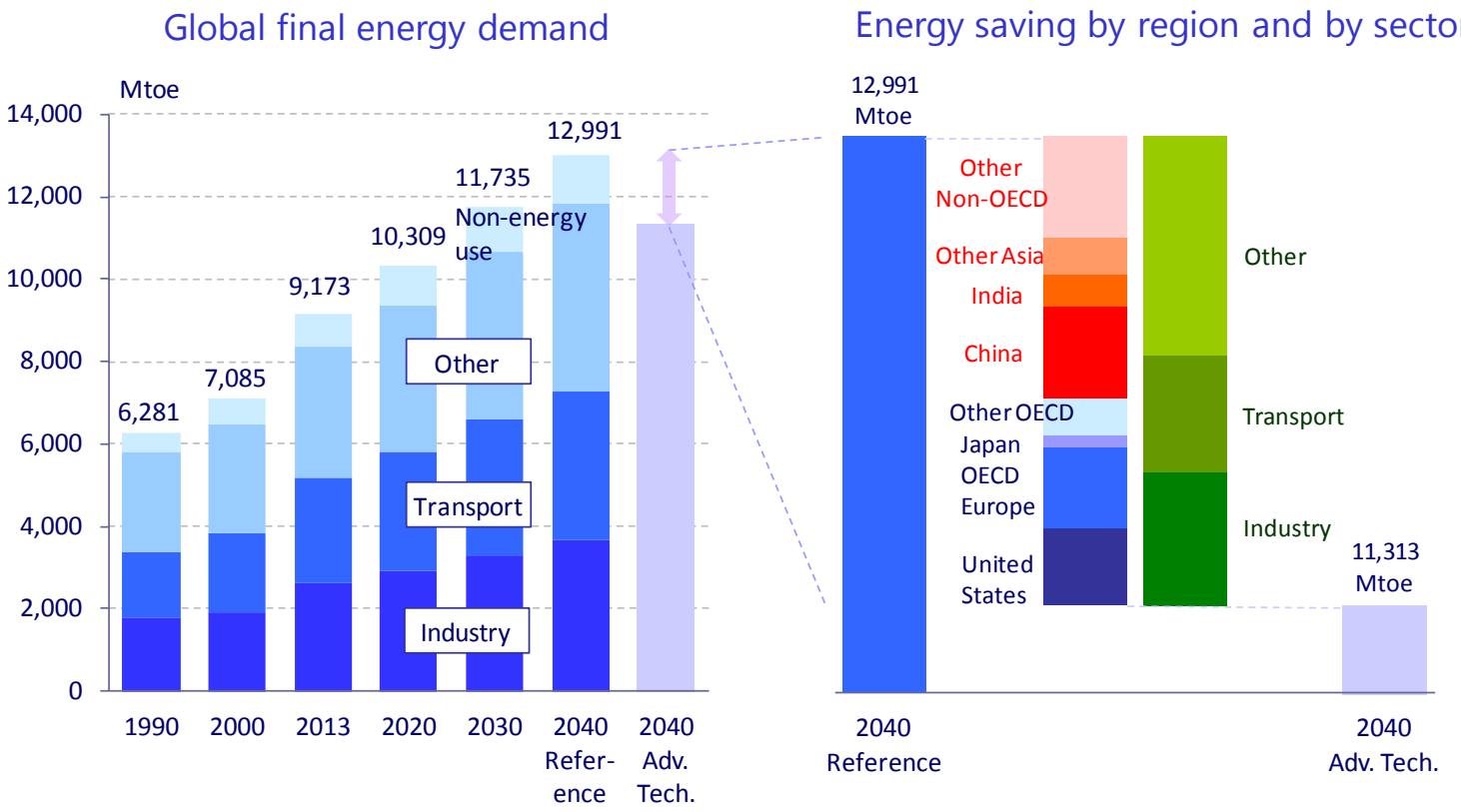
Solid lines: Reference
Dashed lines: Adv. Tech.



- While Asia including China and India have scarce oil and natural gas resource, coal resource is abundant and this contributes to stabilize energy self-sufficiency.
- Asian fossil fuel self-sufficiency rate has been decreasing and it keeps decreasing not only in the Reference Scenario where demand rapidly increases but also in the Advanced Technology Scenario where energy saving technologies are heavily introduced.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Energy saving in 2040 by region and by sector



- Global final energy demand expands 1.4-fold from 9,173 Mtoe in 2013 to 12,991 Mtoe in 2040 in the Reference Scenario.

- In the Advanced Technologies Scenario, final energy demand in 2040 is reduced by 13% to 11,313 Mtoe. 60% of the energy saving is attributable to non-OECD countries. By sector, "other" sector including residential and commercial sectors accounts for nearly half (47%) of total energy saving.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Conclusion:
IEEJ Energy Outlook through 2040

- Global and Asian primary energy consumption increase 1.4-fold and 1.6-fold through 2040. As energy demand expands rapidly, Asia's energy self-sufficiency rate continues to fall and that change may destabilize the world energy markets. It also results in increasing global CO_2 emissions, causing severe damages to the environment.

- The key to solving these problems are energy saving and the decarbonization of energy use. Energy saving measures include the penetration of the technologies that bring more benefits than costs. With only these "beneficial" technologies, however, it would not be possible to achieve sufficient level of energy saving. Every effort should be made to realize the maximum possible saving of energy consumption, taking more "costly" measures as well.

- Asian emerging countries, including China and India, hold the key to reducing CO_2 and GHG emissions. Without their cooperation, the international community is not able to address the climate change problem. All countries or regions have to adopt maximum measures of efficiency, while maintaining a sustainable economic growth.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

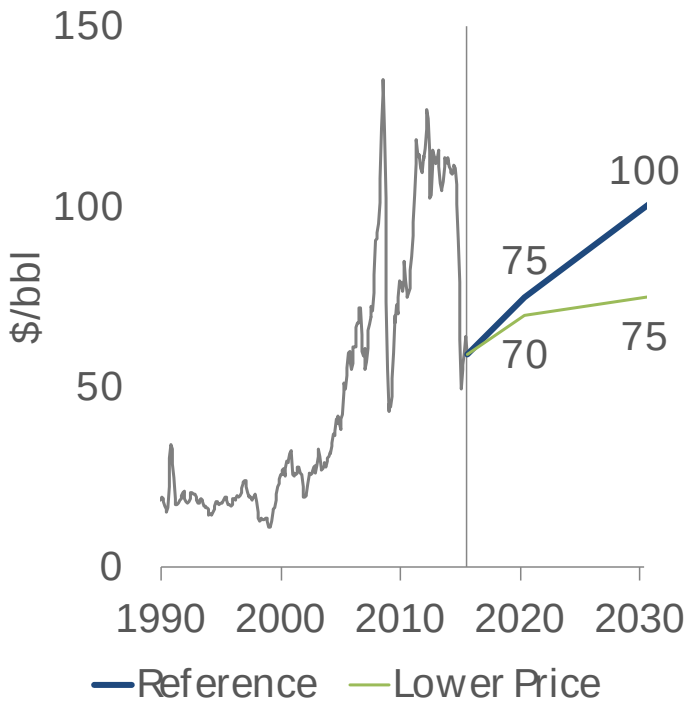
Impact of Lower Oil Price Case

We may see lower prices than in the Reference Scenario

❖ Background of the scenarios

	Reference	Lower Price
Demand	Energy conservation and fuel switching in transport sector progress along the trend.	Strong energy conservation and fuel switching by non-fossil fuel progress.
Supply	**Conventional resources** Development in each country follows its historical trend. **Unconventional resources** Production growth in the United States declines in and after 2020s. Slow development is seen in other countries.	**Conventional resources** Competition among low-cost producers such as OPEC, Russia, etc. continues. OPEC loses effectively its power as a cartel organisation. **Unconventional resources** Reaches to the highest levels both inside and outside the United States.

❖ Assumption of oil price



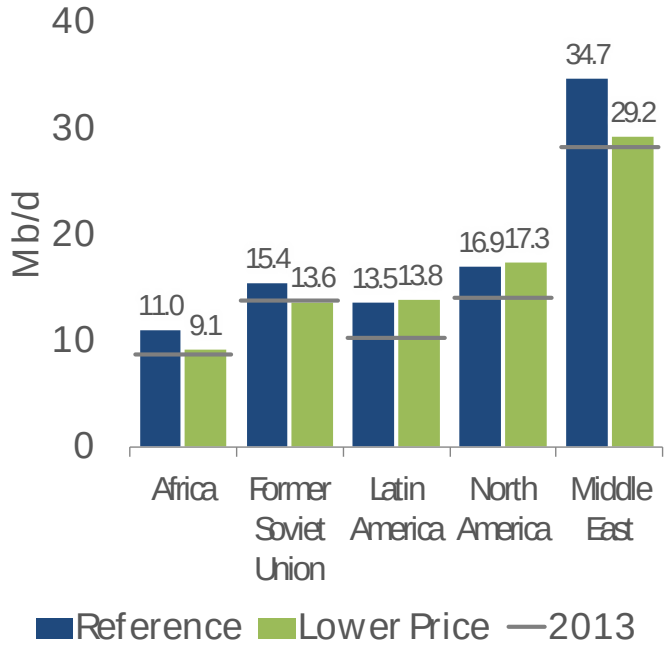
Note: Future prices are in $2014.

Easy supply-demand balance due to factors in supply and demand sides is assumed in the Lower Price Scenario. Real oil price in 2030 in the scenario is premised to be cheaper by 25% than in the Reference Scenario.

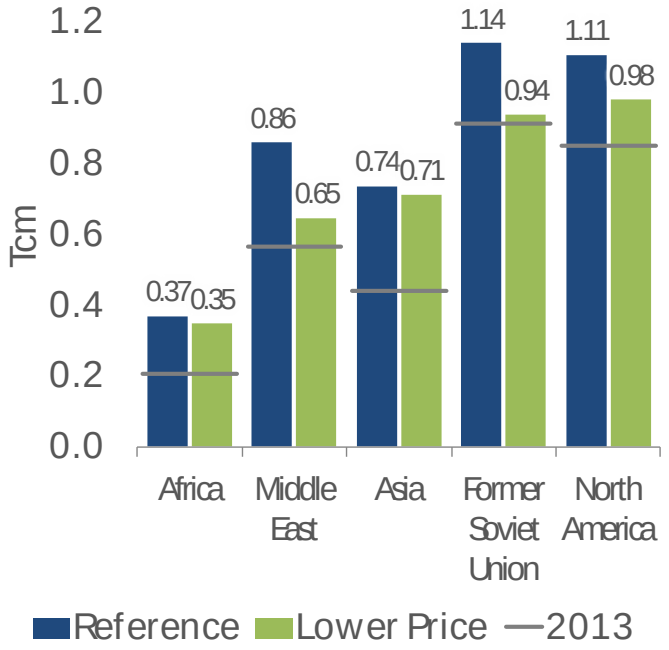
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Depressed production in traditional exporting regions

❖ **Crude oil production in selected regions [2030]**



❖ **Natural gas production in selected regions [2030]**



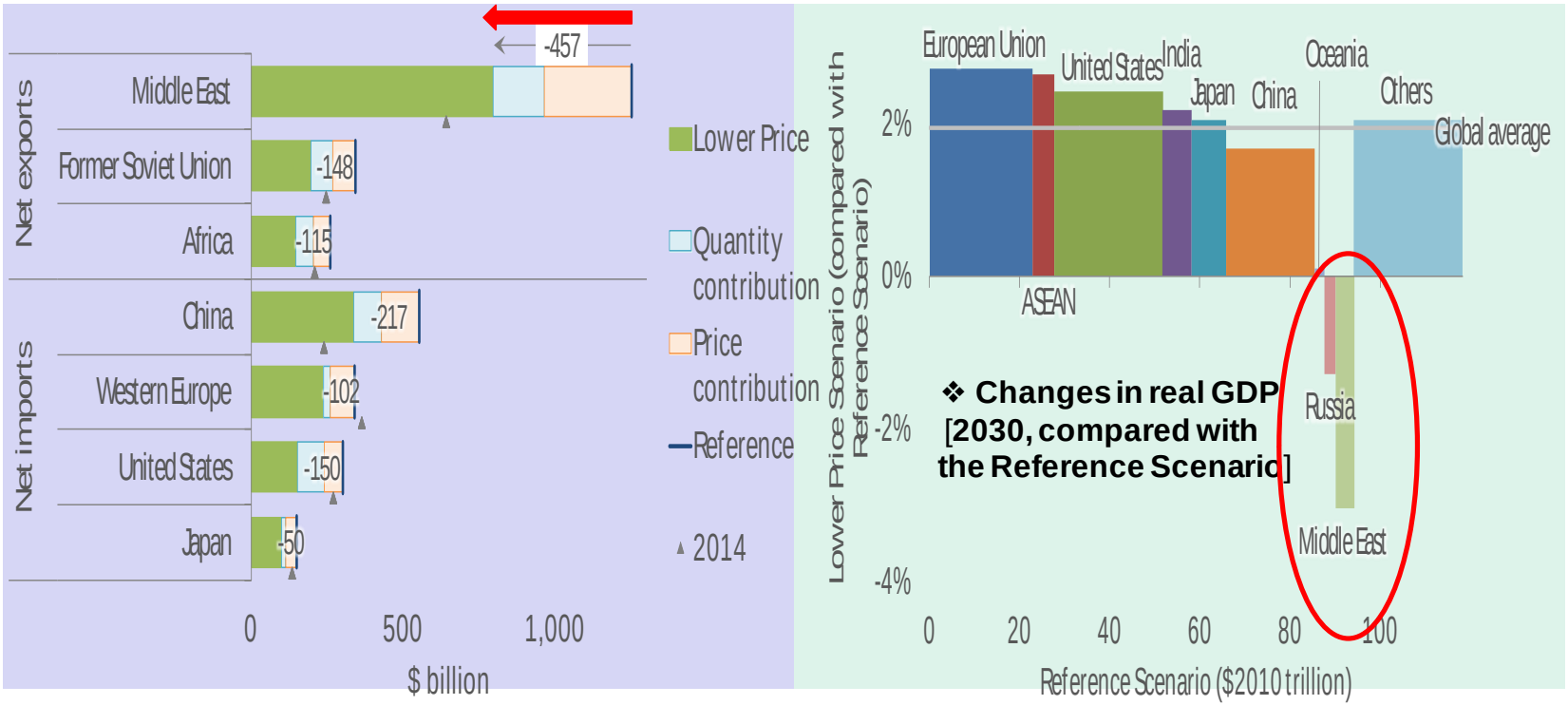
Global oil supply in 2030 is 96.5 Mb/d, increased by just 7.7 Mb/d from today, due to the assumed strong energy conservation and fuel switching to other energies.

Production growth in the Middle East is only 1.0 Mb/d squeezed by large increases in unconventional oil production in North America and others. Russia faces production reduction by 0.8 Mb/d.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Benefit for importing countries thanks to lower imports and price

❖ **Crude oil net imports/exports and GDP in selected regions [2030]**



Oil saving, lower oil price and wider use of unconventional resources make international trade of crude oil* 36% less to $2.8 trillion from $4.4 trillion in the Reference Scenario.

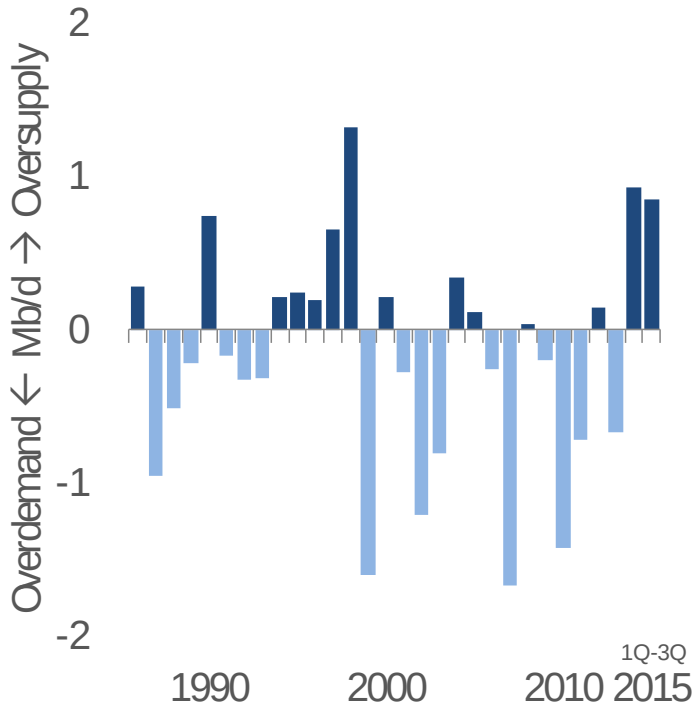
* Among the modelled 15 regions. Nominal value.

China is the most winner in terms of saving of net import spending, getting $217 billion. The United States follows with $150 billion. Net export earning of the Middle East decreases by $457 billion.

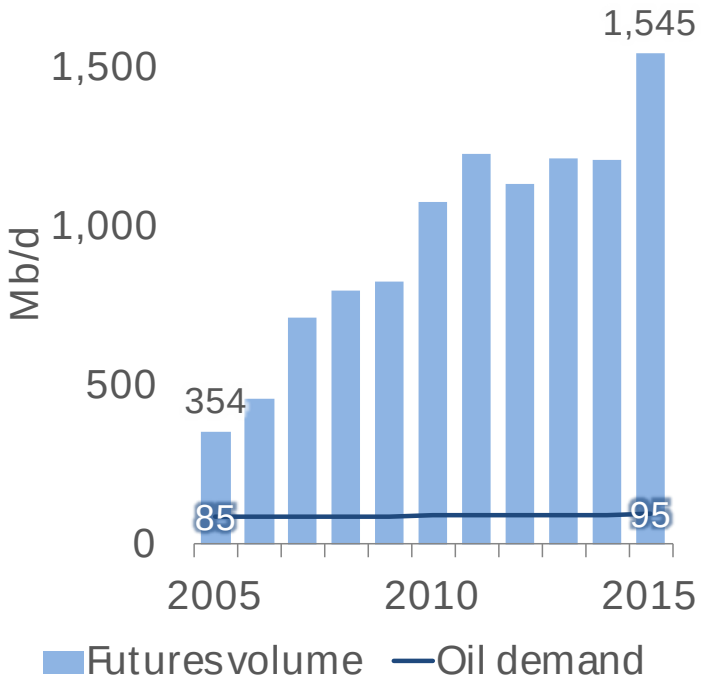
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Lurking risks of high price and volatility

❖ **Global oil supply-demand balance**



❖ **Global oil demand and volumes of futures**



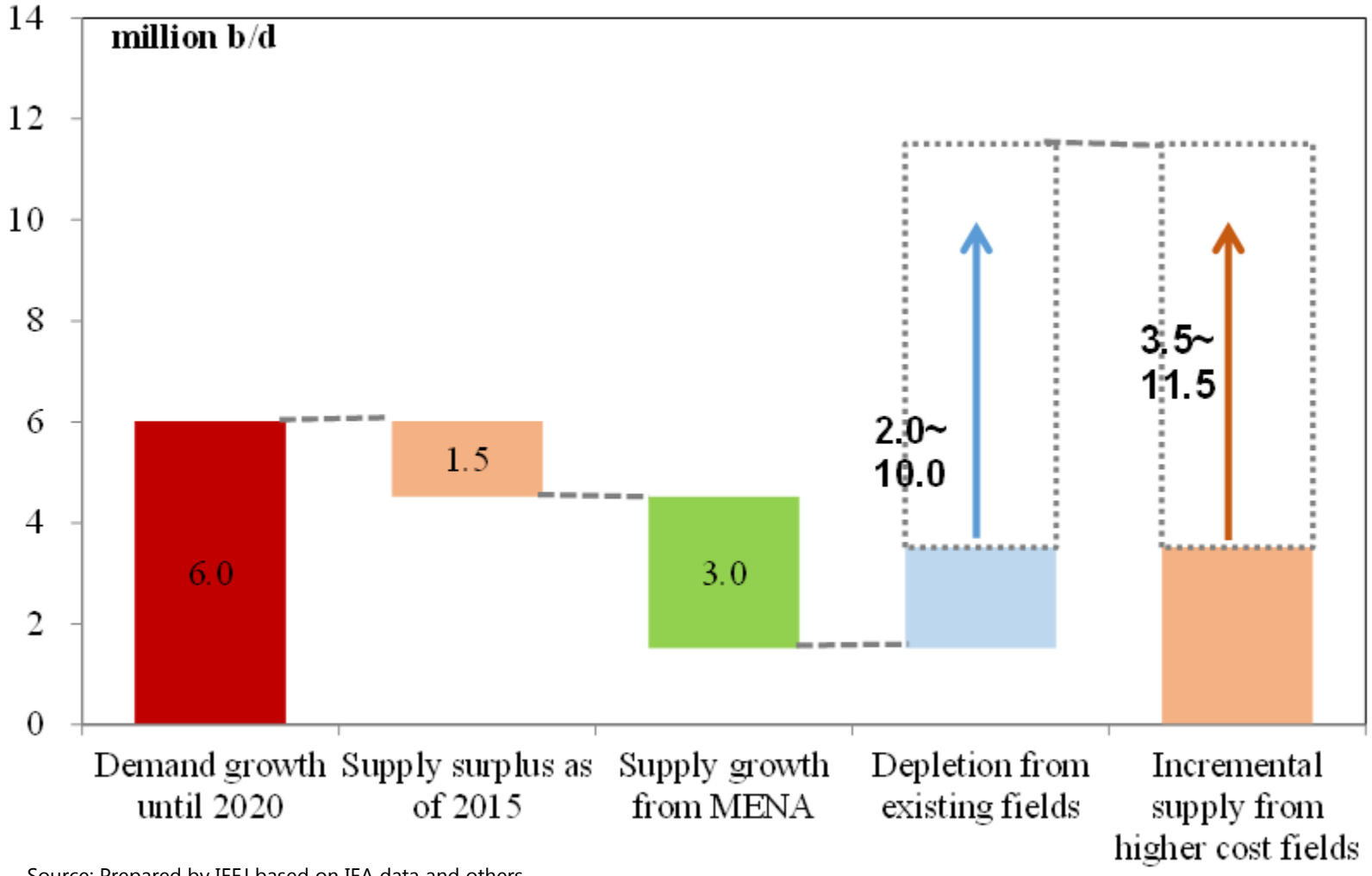
Note: Futures of WTI at NYMEX and Brent at ICE. Source: IEA, CME, ICE

Oversupply since 2014 is as much as 1 Mb/d, the largest in last 16 years. We, however, have no experience that oversupply in such a scale continues for three or more years in last three decades.

Crude oil futures market has grown much faster than actual oil supply and demand. We can not contradict that money and geopolitical factors have huge influence on oil price again.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Need for Higher Cost Oil Production



Source: Prepared by IEEJ based on IEA data and others

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Summary: Lower energy prices

❖ How do we see the current oil price?

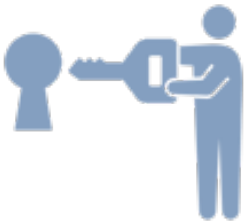
- Similarities can be found between fall of oil price this time and in 1980s:
  1/ Huge contribution by increases in supply from new sources,
  2/ Independent from demand factor caused by economic shock, and
  3/ Competition among OPEC members.
- Oil market has fundamentally nature that draws cycles. Therefore, oil price turns to rise sooner or later. The similarities, however, suggest possibility that the current low price does not end in short term.
- Oil price was much higher than that was indicated by actual supply-demand factor since 2011. We can not contradict that money and geopolitical factors have huge influence on oil price again.
- There is risk of supply-demand imbalance in the future due to the absence of proper investment under extreme unstable prices. Dialogue and cooperation between producers and consumers and those among consumers play a important role for sustainable development.

❖ Impact by lower prices [2030]

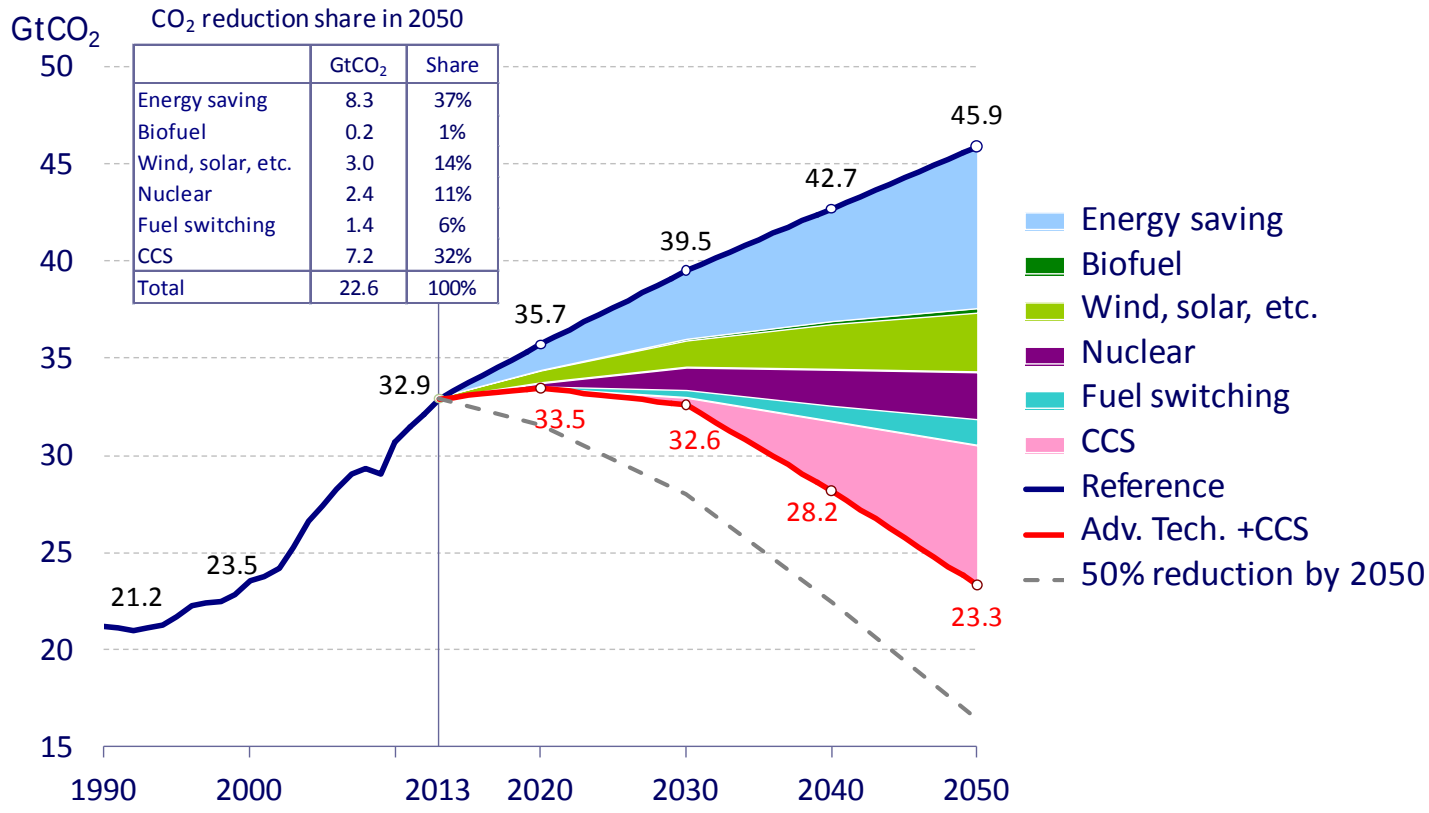
- We can assume $75/bbl or lower oil price if policy-driven fossil fuel saving and wider utilisation of unconventional resources by technology development ease supply-demand balance.
- Global oil supply in 2030 is 96.5 Mb/d, increased by just 7.7 Mb/d from today, due to the assumed strong energy conservation and fuel switching. Production growth in the Middle East is only 1.0 Mb/d squeezed by large increases in unconventional oil production in North America, etc. Russia faces production reduction by 0.8 Mb/d.
- Lower import quantity and price result in substantial low import spending for crude oil. The largest fruits are in hands of China.
- Reduction in energy import spending supports the global economy with 1.9% of expansion, especially for importing countries. The situation exerts downward pressure on oil producing countries in the Middle East and others, which revenue depends heavily on energy exports.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Pragmatic Approach to Address Climate Change



CO_2 Emissions Reduction by Technology (World)



CO_2 reduction share in 2050

	$GtCO_2$	Share
Energy saving	8.3	37%
Biofuel	0.2	1%
Wind, solar, etc.	3.0	14%
Nuclear	2.4	11%
Fuel switching	1.4	6%
CCS	7.2	32%
Total	22.6	100%

- In the Advanced Technologies Scenario, the global CO_2 emissions are reduced by various technological options, including energy saving, enhancement of power generation efficiency, renewables, nuclear, and CCS. Altogether these options contribute to large CO_2 emissions reduction.
- To achieve halving world CO_2 emissions from current levels, additional measures such as innovative technological development, eco-friendly urban development are required in the long-term.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

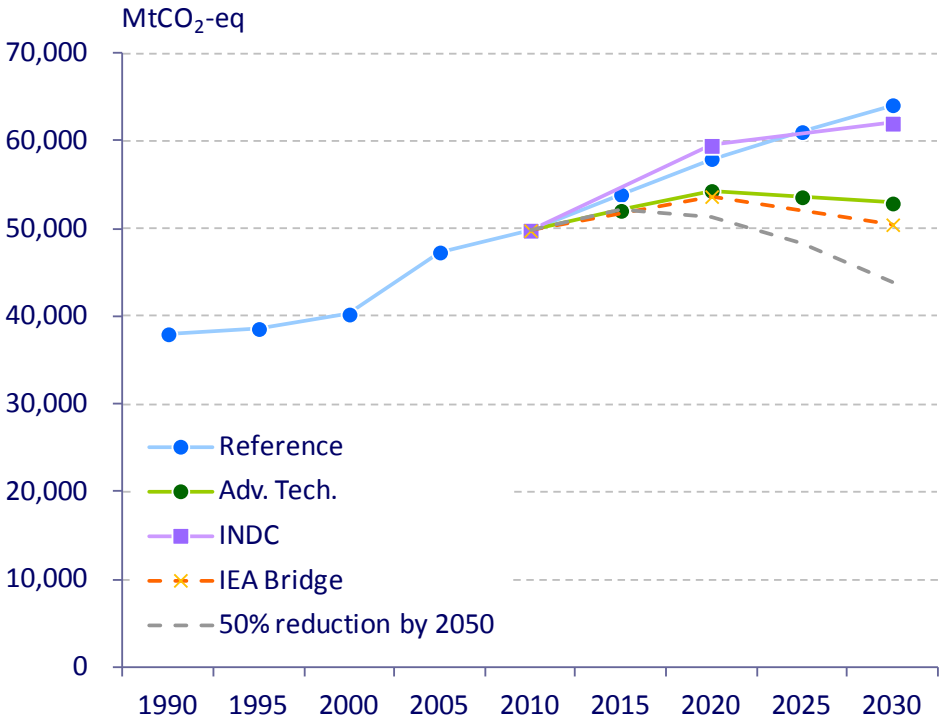
Intended Nationally Determined Contributions (INDCs) of major countries

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

- In advance of United Nations Climate Change Conference (COP21) in Nov. 2015, the participating countries has submitted the Intended Nationally Determined Contributions (INDCs) which present the post-2020 climate actions each country intend to take.
- By Oct 1st, 117 countries and regions (totaling 144 countries) has submitted their INDCs.
- The 8 major countries and regions shown above cover 65% of global GHG emissions in 2010.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Comparison of INDCs with the Reference/Adv. Tech. Scenarios

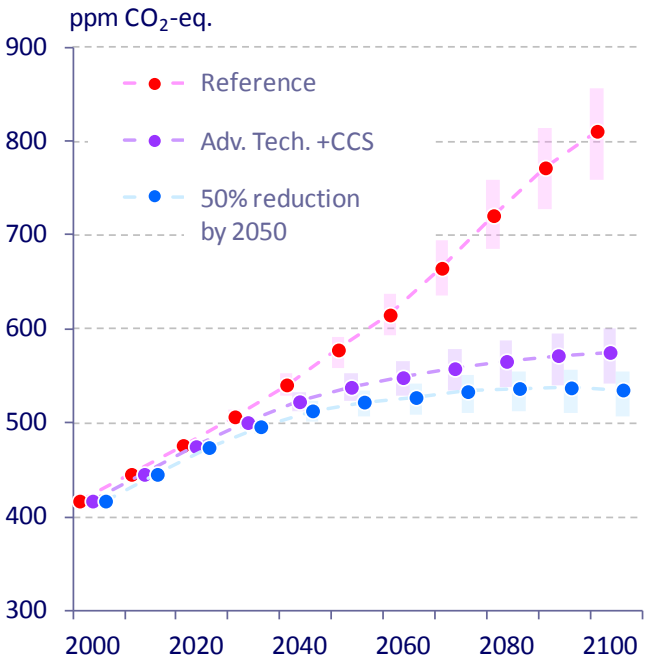


- The future evolution of global GHG emissions suggested by the INDCs of the 8 parties traces a path similar to that of the Reference Scenario. Thus climate actions based on the INDCs are not sufficient to reach the Advanced Technologies Scenario, being far behind the target of "50% reduction by 2050."

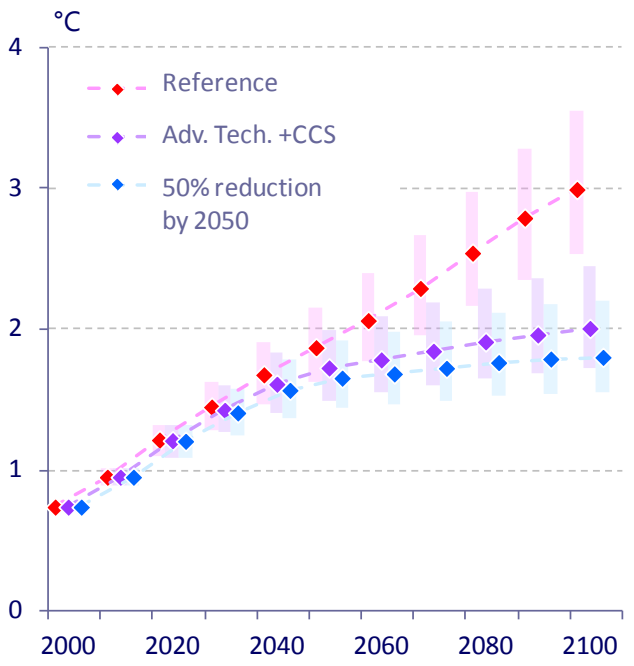
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Reference, Adv. Tech. and "50% reduction by 2050" scenarios

GHG concentration



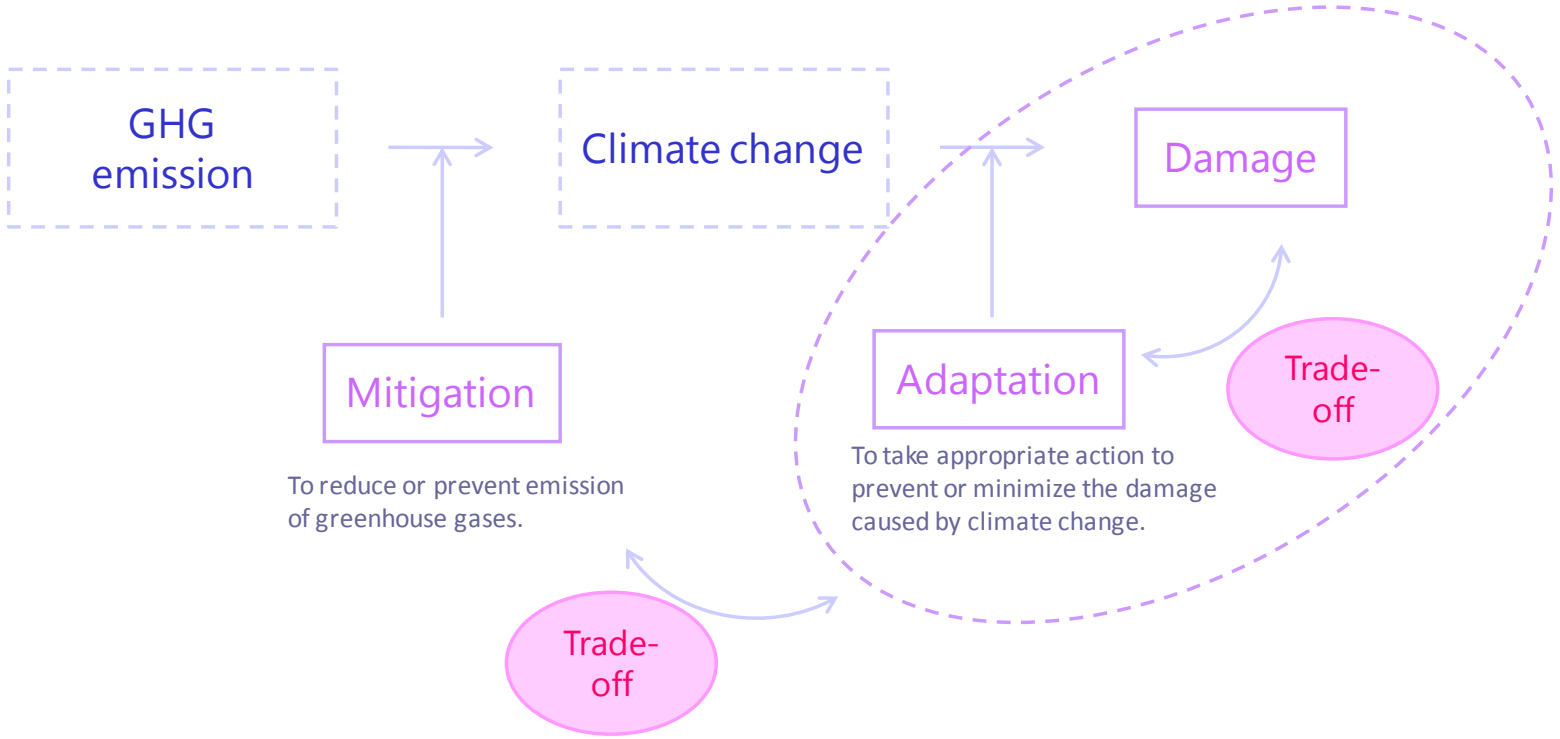
Temperature change from 1850-1900



- The results of the Reference Scenario correspond to a level of GHG concentration in the atmosphere in 2100 in the range of 760-860 ppm (CO2-eq.), with an average temperature rise from 1850-1900 reaching between 2.8-4.0° C the same year.
- On the other hand, the Advanced Technologies Scenario is comparable to GHG concentrations in 2100 of 540-600 ppm (CO2-eq.), with an average rise in temperature between 1.7 and 2.4° C. This is lower than 2.5° C and possibly lower than 2° C by 2100.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Mitigation, adaptation and damage costs



- There is a trade-off relationship among the mitigation, adaptation and damage costs. It is impossible to reduce all the three costs at the same time.
- It would be realistic to expect a balance among three, while minimizing the total cost.

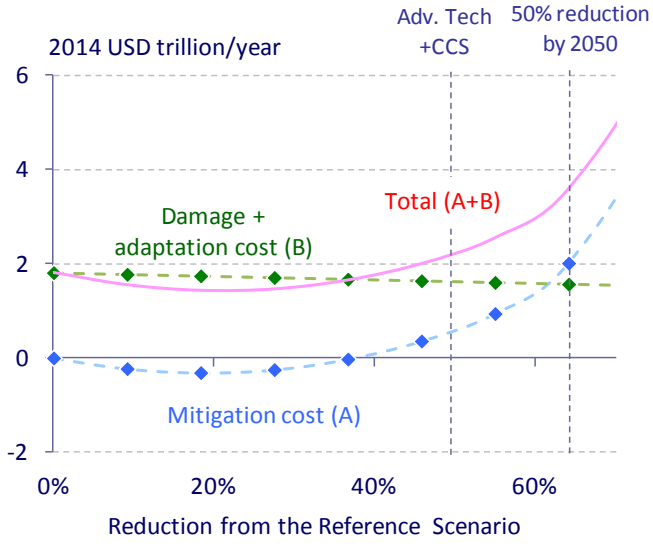
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Mitigation vs. adaptation and damage

- In 2050 the temperature rise is relatively small (less than 2° C from the latter half of the 19th century), resulting in smaller damage.

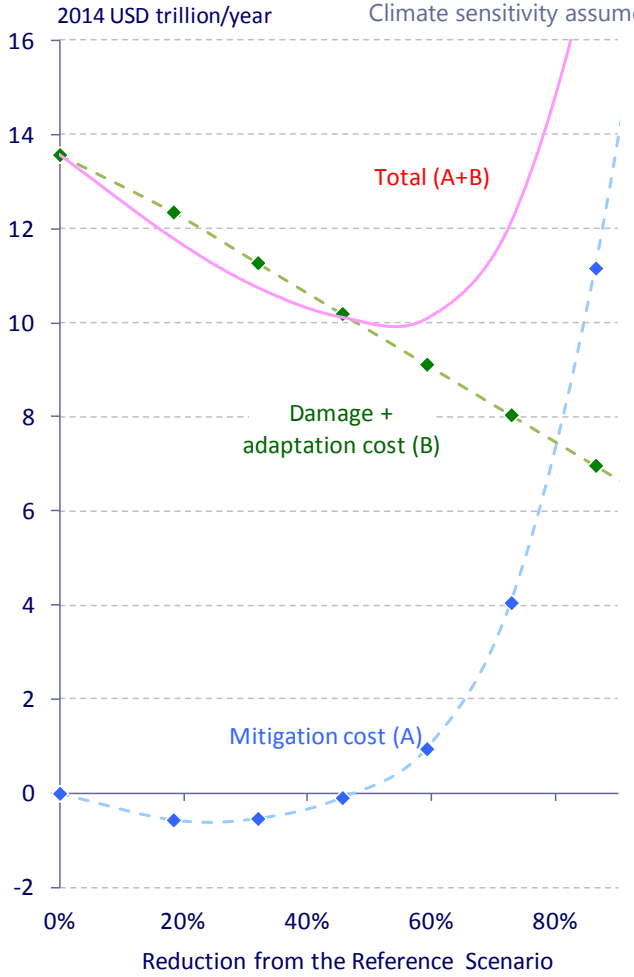
- CO_2 reduction brings benefits (negative costs) to a certain extent due to the savings of fossil fuel consumption. If the reduction ratio exceeds that of the Advanced Technologies Scenario, however, the cost increases enormously.

- The damage costs also become tremendous after 2100. Thus a long-term perspective is indispensable to address the problem of climate change.



2050

Mitigation cost: estimated by IEEJ
Damage + adaptation cost: calculated using the formula in the DICE 2013R model
Climate sensitivity assumed at 3°C.



2100

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

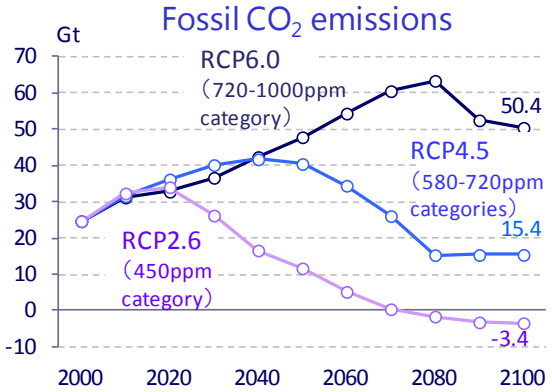
450 ppm category in IPCC 5th Assessment Report

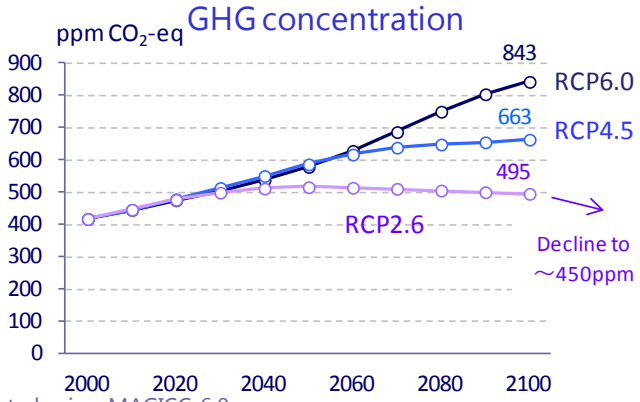
Scenarios in IPCC AR5 WG3

GHG concentration in 2010, ppm CO_2-eq	Sub-category	Change in GHG emissions from 2010 to 2050, %	2100 temperature change relative to 1850-1900 (℃)*
450 (430-480)	Overshoot (vast majority)	-72 to -41	1.5 - 1.7 (1.0 - 2.8)
500 (480-530)	No overshoot	-57 to -42	1.7 - 1.9 (1.2 - 2.0)
	Overshoot	-55 to -25	1.8 - 2.0 (1.2 - 3.3)
550 (530-580)	No overshoot	-49 to -19	2.0 - 2.2 (1.4 - 3.6)
	Overshoot	-16 to +7	2.1 - 2.3 (1.4 - 3.6)
(580-650)		-38 to +24	2.3 - 2.6 (1.5 - 4.2)
(650-720)		-11 to +17	2.6 - 2.9 (1.8 - 4.5)
(720-1000)		+18 to +54	3.1 - 3.7 (2.1 - 5.8)

*Temperatures in parentheses include carbon cycle and climate system uncertainties

Source: IPCC AR5 WG3





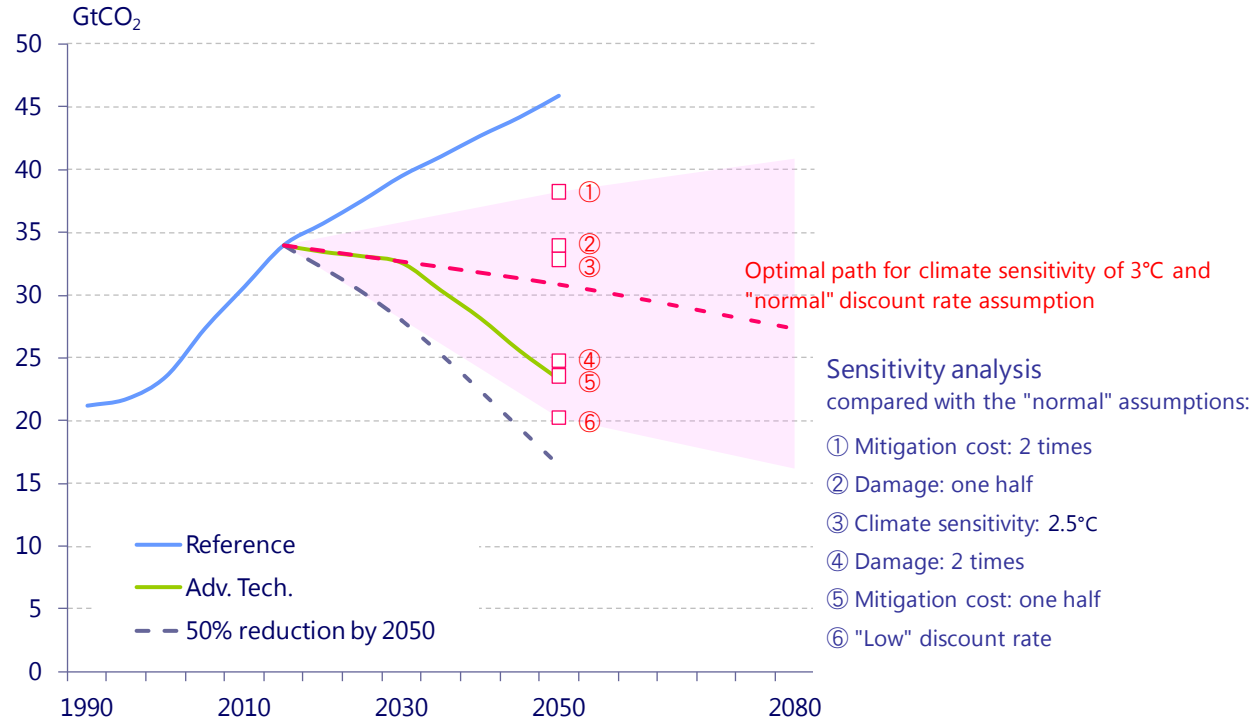
※Calculated using MAGICC 6.0

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.

- For the Representative Concentration Pathway (RCP) 2.6, which is a typical scenario for the "450ppm" category, the GHG concentration is estimated around 500 ppm CO_2-eq in 2100. In a longer term, the concentration declines to some 450 ppm.
- This scenario assumes 64% reduction of fossil CO_2 from 2010 to 2050, and negative emissions after 2070. It is much more ambitious than the "50% reduction by 2050" target.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Example of the calculation of the long-term optimal path



- The optimal path considering mitigation and adaptation costs and climate damage shows a downward trend of CO_2 emission from the current level, although the uncertainty is very large.
- These calculations suggests that the paths to reduce 50% or more from current levels by 2050 result in enormous mitigation costs compared with the damage, and can not be regarded as optimal, even assuming lower discount rates.
- In order to achieve zero or negative emissions in a longer term, technological innovation would be needed to reduce the cost hike with larger CO_2 reduction ratios.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Innovative technology development towards the future

Technology		Overview and challenges
Reducing the production of CO_2	**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 a 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.
Preventing the release of CO_2 to the atmosphere	**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.
Utilizing the produced CO_2	**Carbon Capture and Utilization (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.
	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.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Conclusion: Addressing the climate change issues

- With the climate actions suggested by the INDCs of major countries, it would not be possible to curb GHG emissions to sufficient levels. It is strongly expected that each party tries the best to reduce GHG emissions further.

- At he same time, we should note that there is a trade-off relationship among the mitigation, adaptation and damage costs. It would be realistic to expect a balance among the three, while minimizing the total cost. Otherwise no international agreements would be obtained.

- From this point of view, it is necessary to take actions against climate change considering various scenarios and options other than only the “450ppm” scenario.

- Long-term measures have to be taken beyond 2050 to reduce global CO_2 emissions drastically. In addition to existing technologies, innovative technologies including CCS, CCU and artificial photosynthesis have to be developed to accomplish the target.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Thank you for your attention.

We provide Global Perspectives on Economic, Energy and Environmental (3E) issues.

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