

A Japanese View on the World Energy Future

The Impacts of Lower Oil Prices

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Emerging landscape with regard to global energy market

- Volatile crude oil price
- Impacts of Unconventional Oil & Gas Development
 - Impacts of US Shale Gas Revolution
 - Impacts of US Energy Independence
- Growing energy demand in Asia and its implication to global energy security
- Emerging concerns for energy supply constraints
 - Geopolitical risks, resource nationalism and issues of market power
 - Ongoing “MENA crisis”, “Iranian crisis”, Ukraine crisis, etc.
 - Lack of timely investment in resource development
 - Importance of stability of energy transportation
- Environmental challenges for sustainability
 - Climate change and global environmental problems
 - Local and regional environmental problems
- Impacts of “March 11th” and Japan’s Energy Policy Review

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.

IEE JAPAN Assumptions for the Advanced Technologies Scenario



In this scenario, each country further enhances policies on energy security and addresses global warming. Technological developments and international technology transfers are promoted to further expand the diffusion of innovative technologies.

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

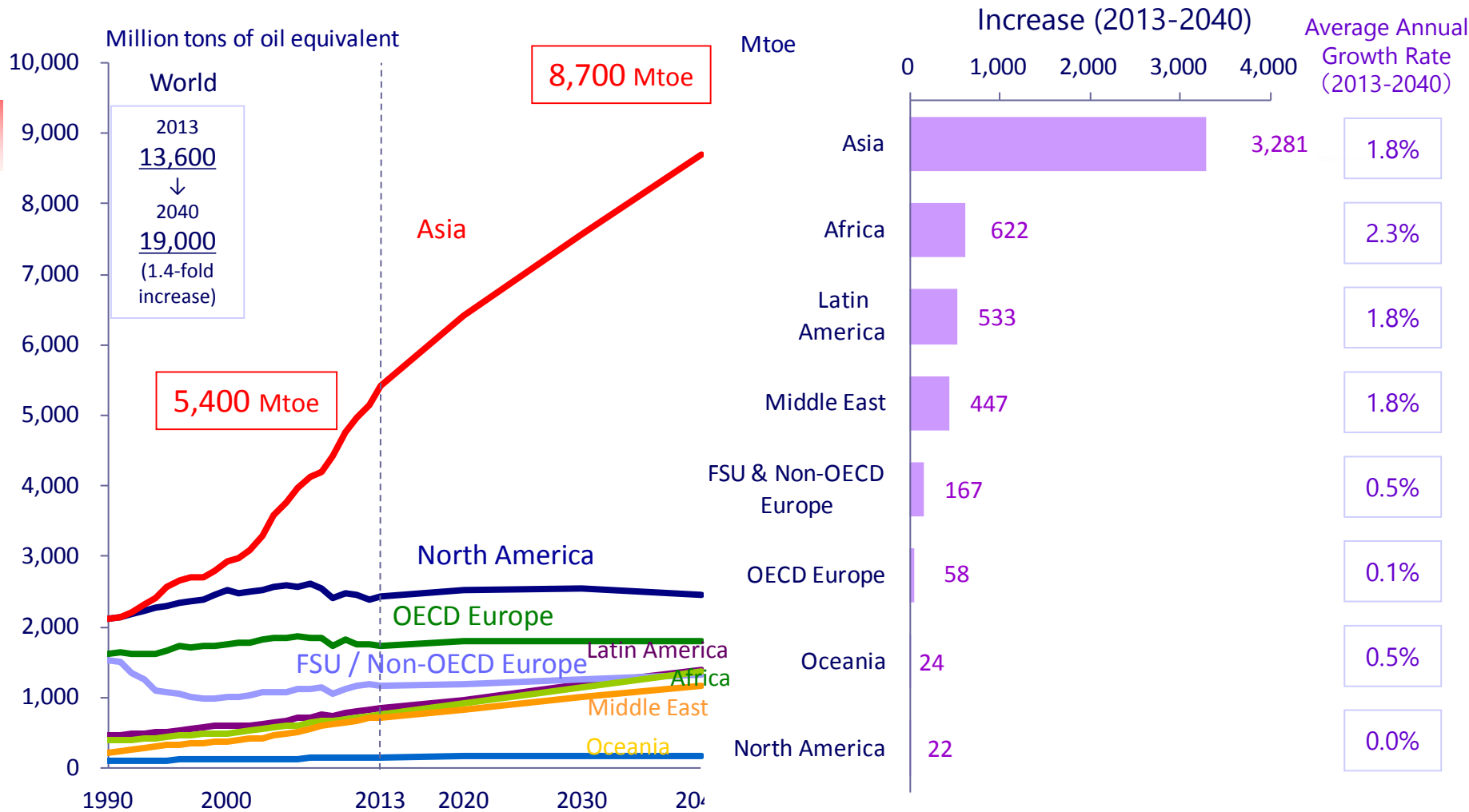
Coal-fired power plants (USC, IGCC, IGFC) and natural gas MACC (More Advanced Combined Cycle) plants will diffuse further.

■ 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).



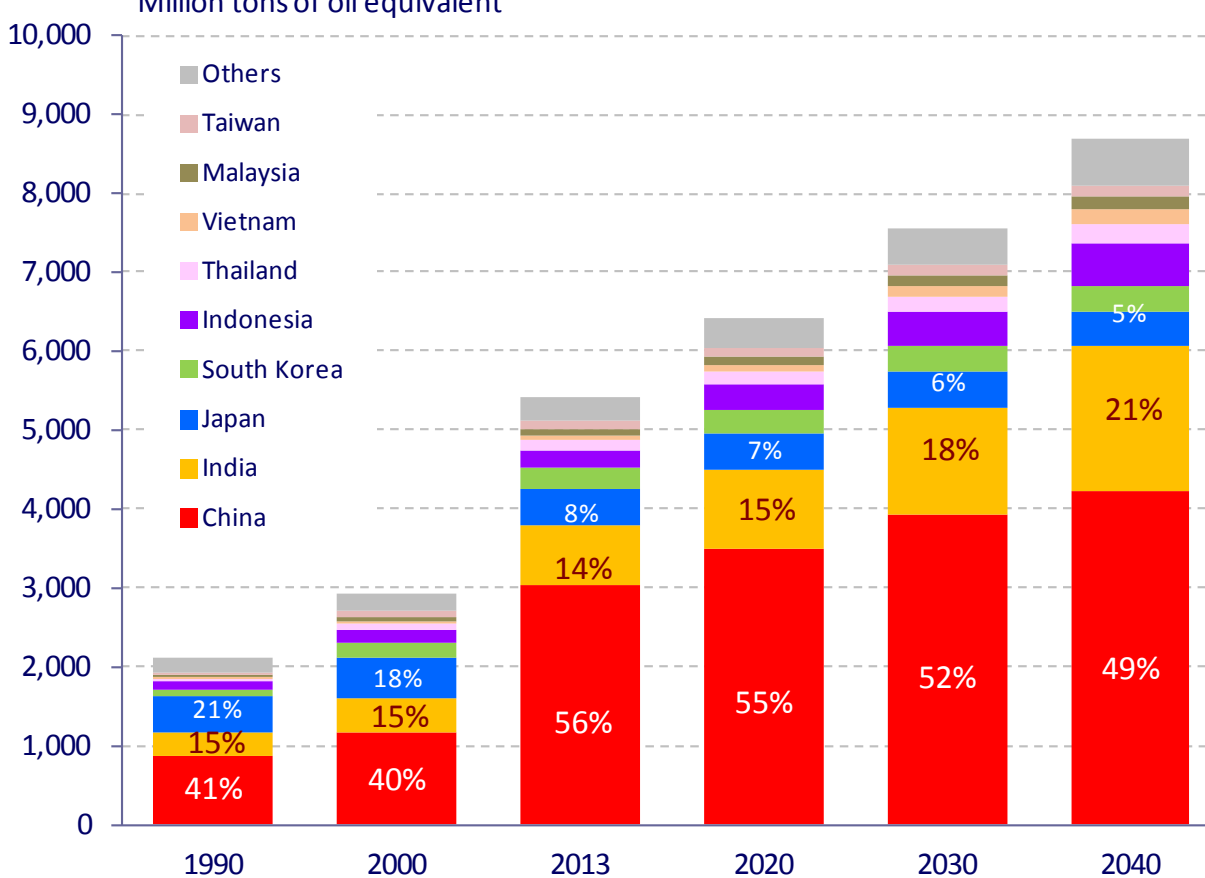
Primary Energy Demand Outlook Reference Scenario



- Under the steady economic growth assumption, Asian energy consumption in 2040 increases 1.6-fold from the present level (from 5.4 billion tons in 2013 to 8.7 billion tons in 2040).
- Non-OECD countries account for about 90% of global energy consumption increase between 2013 and 2040.

Primary Energy Demand (Asia)

Million tons of oil equivalent



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 expands 70% in 2040.
- Japan's energy consumption declines as a result of progress in energy efficiency combined with a maturing economy and a decreasing population. Its share of Asian energy consumption shrinks from 8% to 5%.

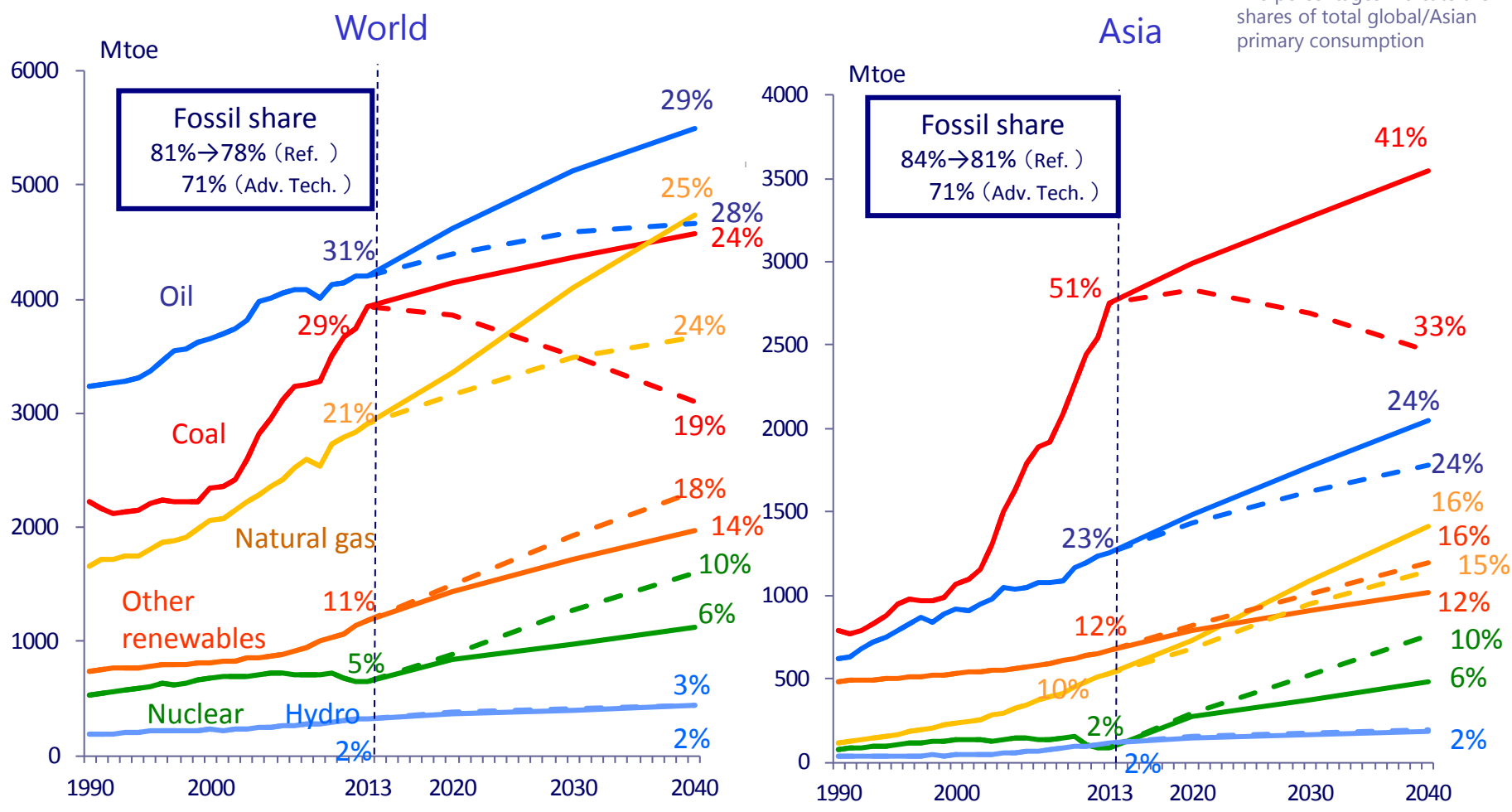


Primary Energy Demand by Source

Solid lines: Reference
Dashed lines: Adv. Tech.



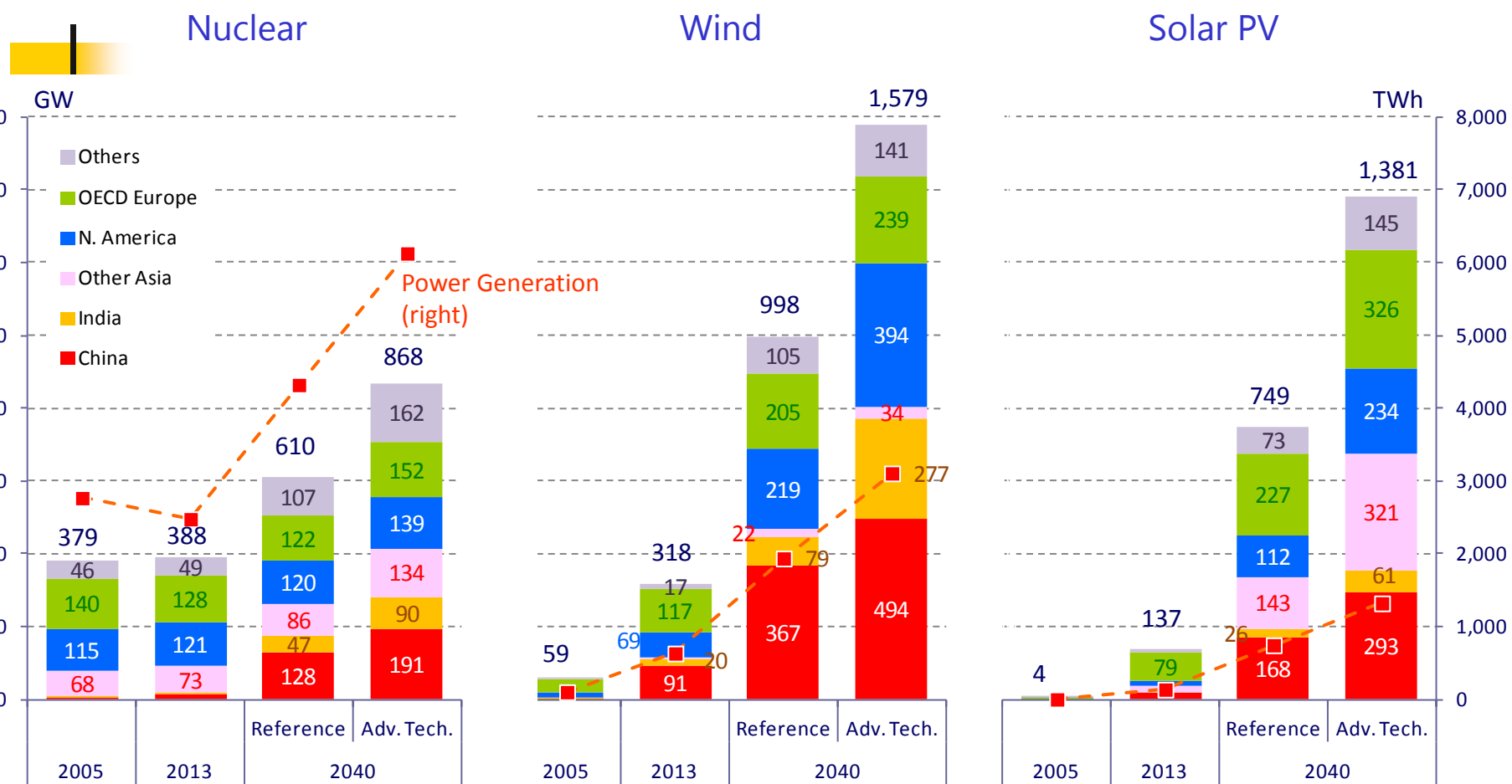
The percentages indicate the shares of total global/Asian primary consumption



- In both the Reference and Advanced Technologies 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 Technologies 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 Technologies Scenario.



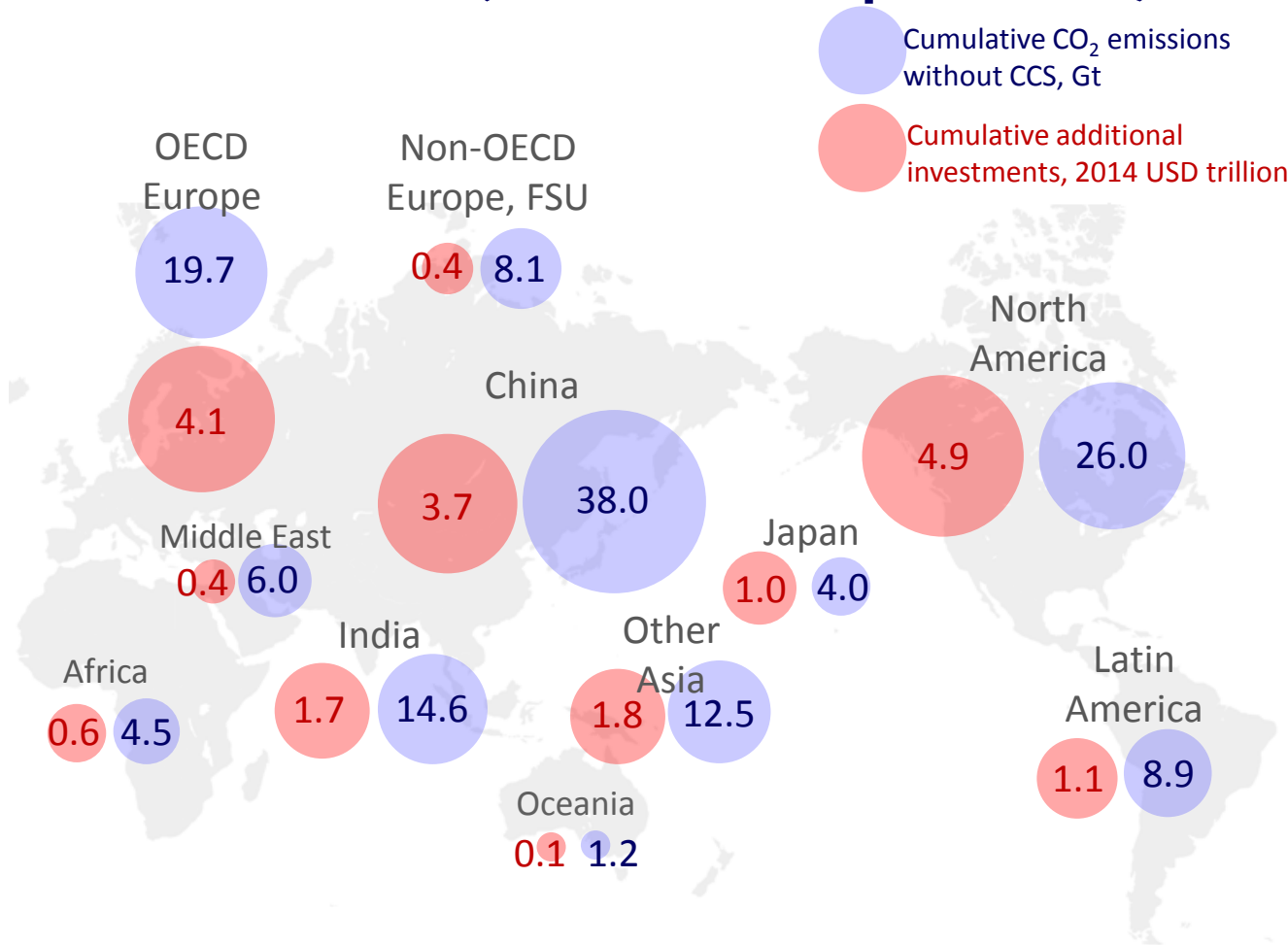
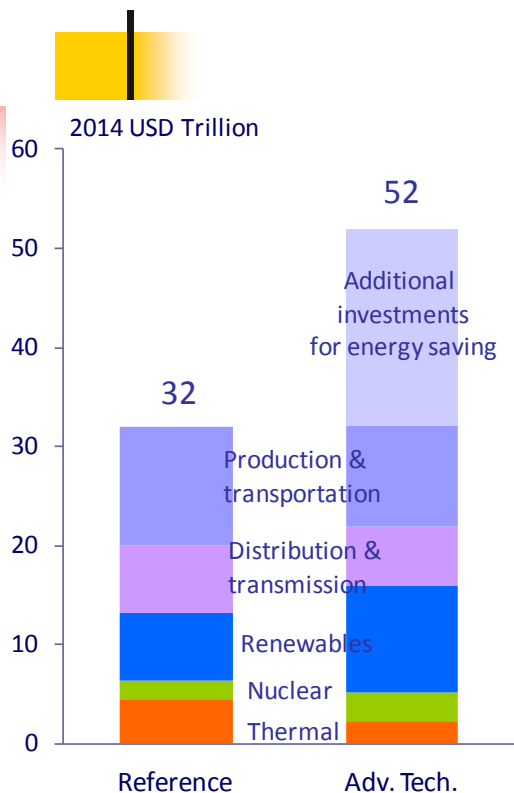
Outlook for nuclear and renewable power capacities



- In the Reference Scenario, global nuclear, photovoltaic generation capacity, and wind power expand 1.6-fold, 3.1-fold, and 5.5-fold, respectively, from 2013 to 2040. In the Advanced Technologies Scenario they are 2.2-fold, 5.0-fold, and 10.1-fold, respectively.
- In particular, expansions in Asia are significant and China and India account for nearly half in all technologies in the Advanced Technologies Scenario.

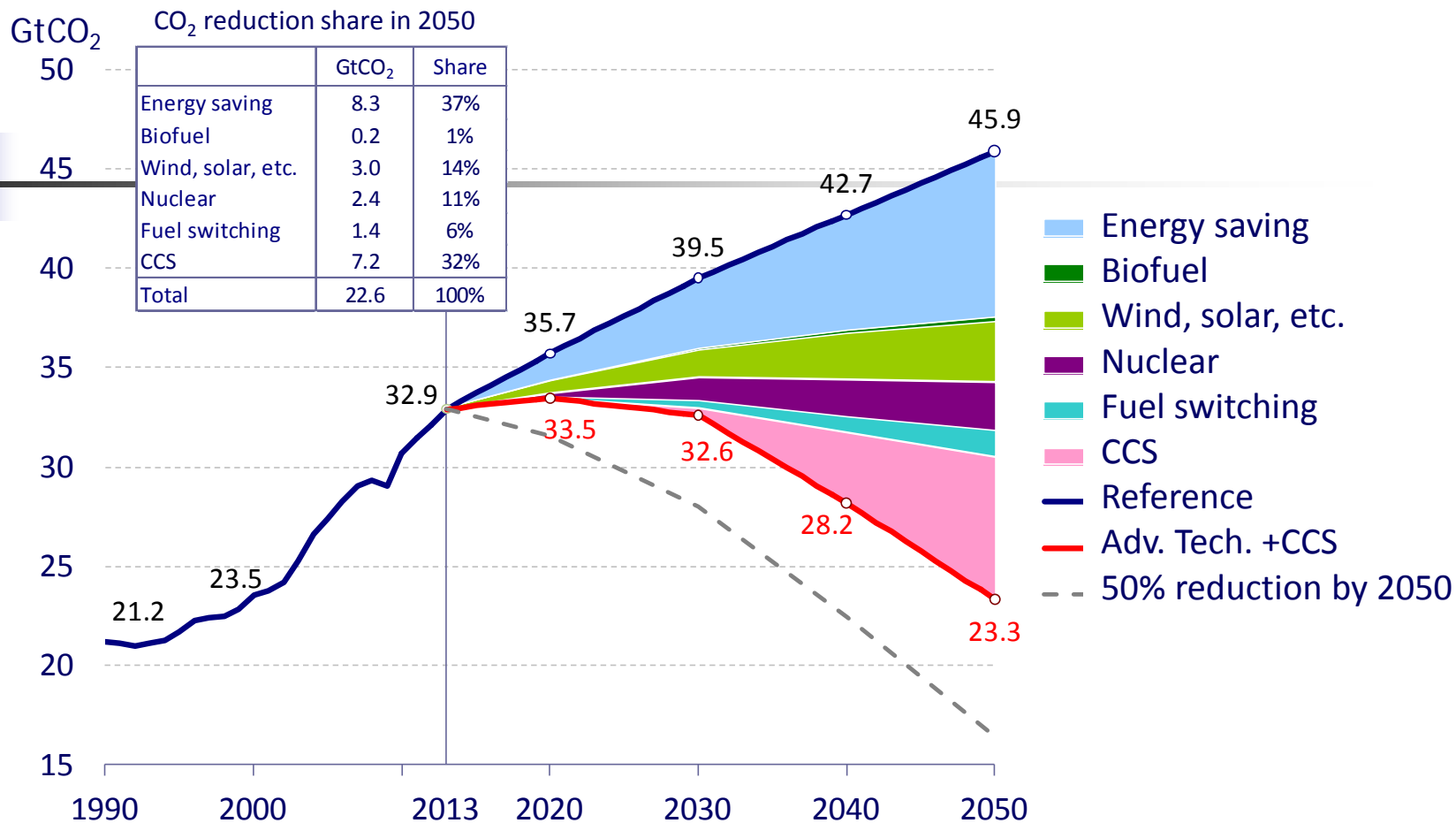


Required Capital Investment (cumulative up to 2040)



- On the supply side, while energy supply decreases in the Advanced Technologies Scenario, investments on renewable energy (etc.) expand and the cumulative investments up to 2040 are the same level as the Reference Scenario.
- On the demand side, additional investments of over 20 trillion USD are required for energy savings. Asian countries, including China and India, account for 42% of the additional investments.

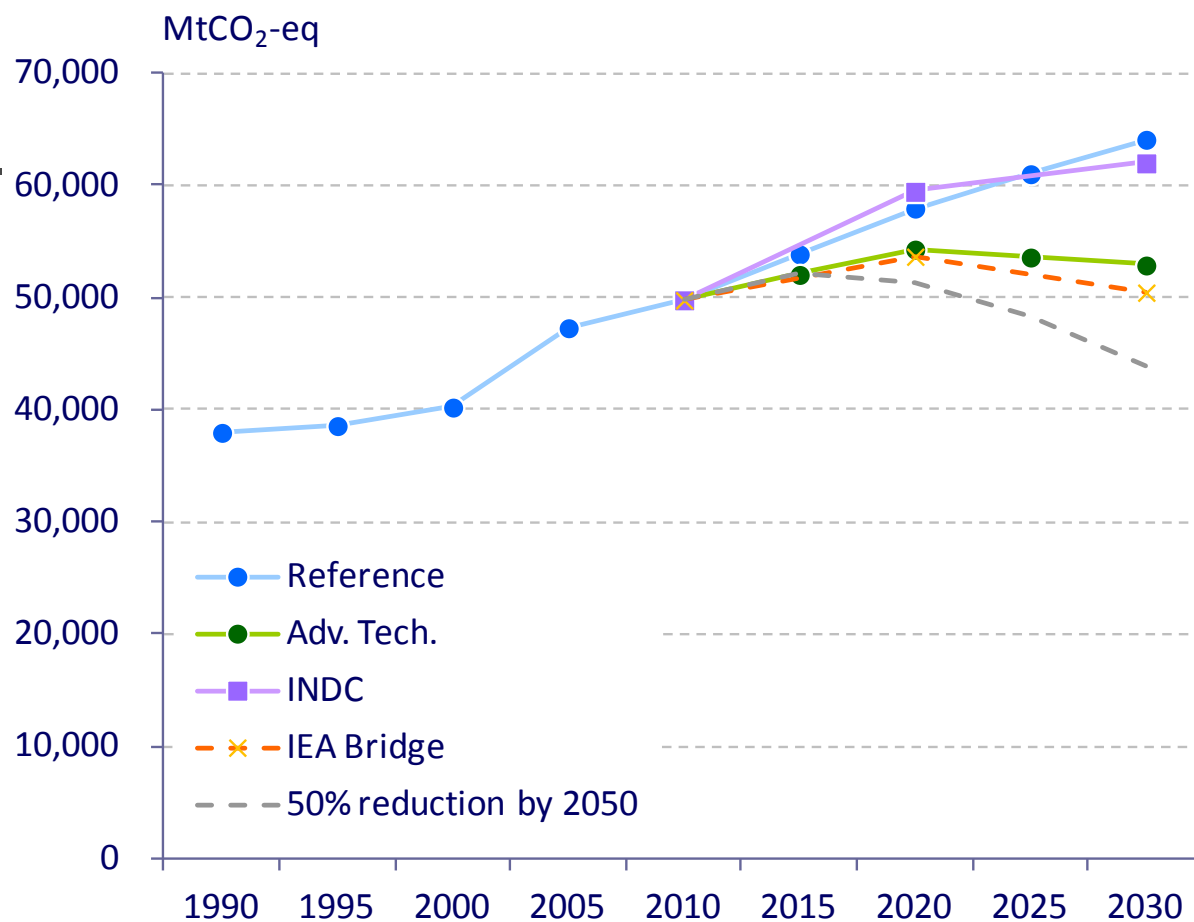
CO₂ Emissions Reduction by Technology (World)



- In the Advanced Technologies Scenario, the global CO₂ 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 CO₂ emissions reduction.
- To achieve halving global CO₂ emissions from current levels, additional measures such as innovative technological development and eco-friendly urban development are required in the long-term.

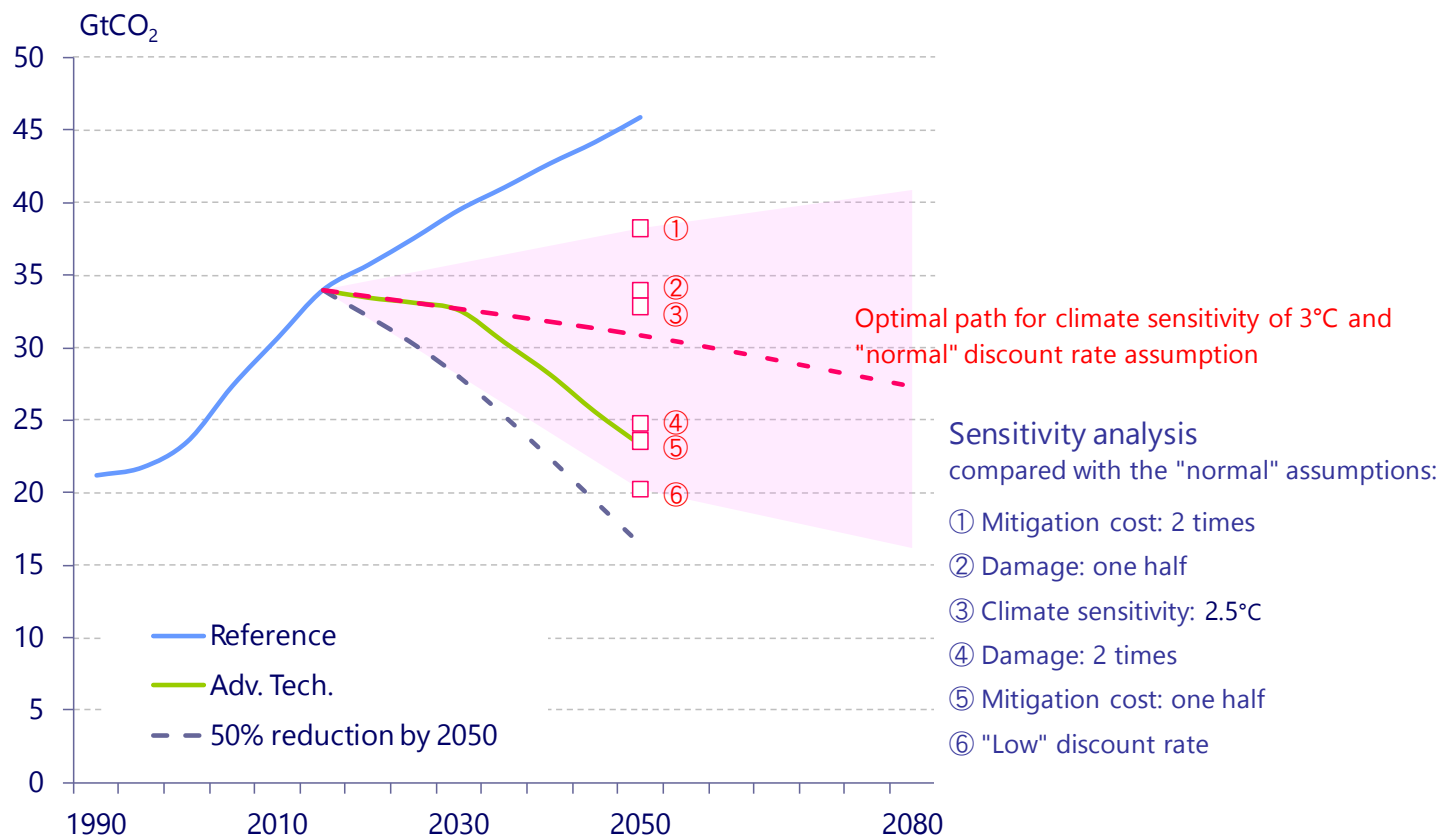
Source: IEEJ, "Asia/World Energy Outlook 2015"

Comparison of INDCs with the IEEJ Outlook



- 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."

Example of the calculation of the long-term optimal path



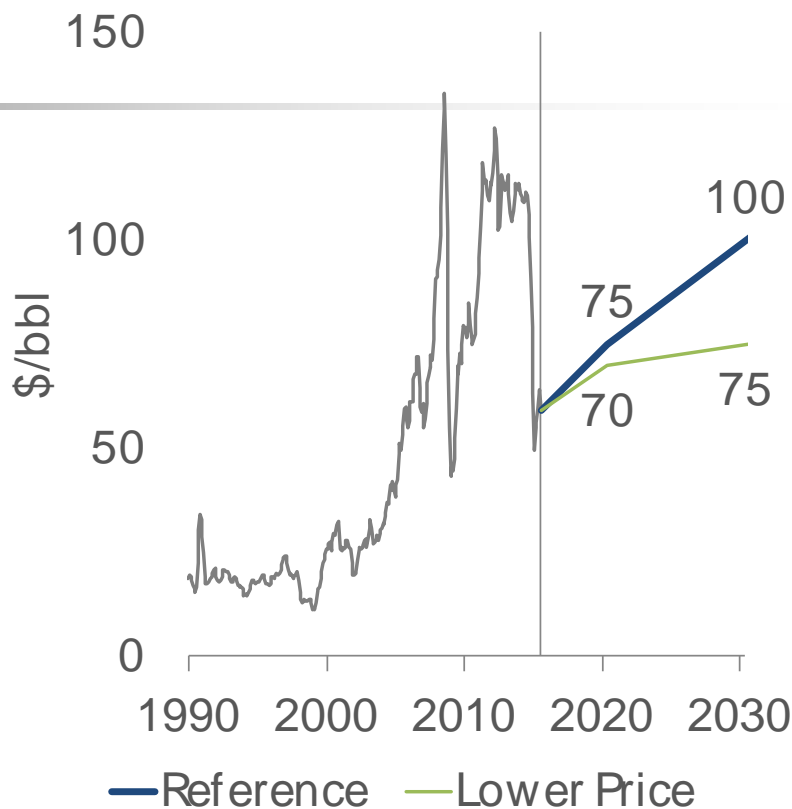
- The optimal path considering mitigation and adaptation costs and climate damage shows a downward trend of CO₂ emission from the current level, although the uncertainty is very large.
- These calculations suggest that the paths to reduce 50% or more from current levels by 2050 result in enormous mitigation costs compared with the damage, and cannot 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 CO₂ reduction ratios.

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 with the trend.	Strong energy conservation and fuel switching by non-fossil fuel progress.
Supply	<p>Conventional resources Development in each country follows its historical trend.</p> <p>Unconventional resources Production growth in the United States declines in and after 2020s. Slow development is seen in other countries.</p>	<p>Conventional resources Competition among low-cost producers such as OPEC, Russia, etc. continues.</p> <p>Unconventional resources OPEC effectively loses its power as a cartel organisation. Reach the highest levels both inside and outside the United States.</p>

❖ Assumption of oil price

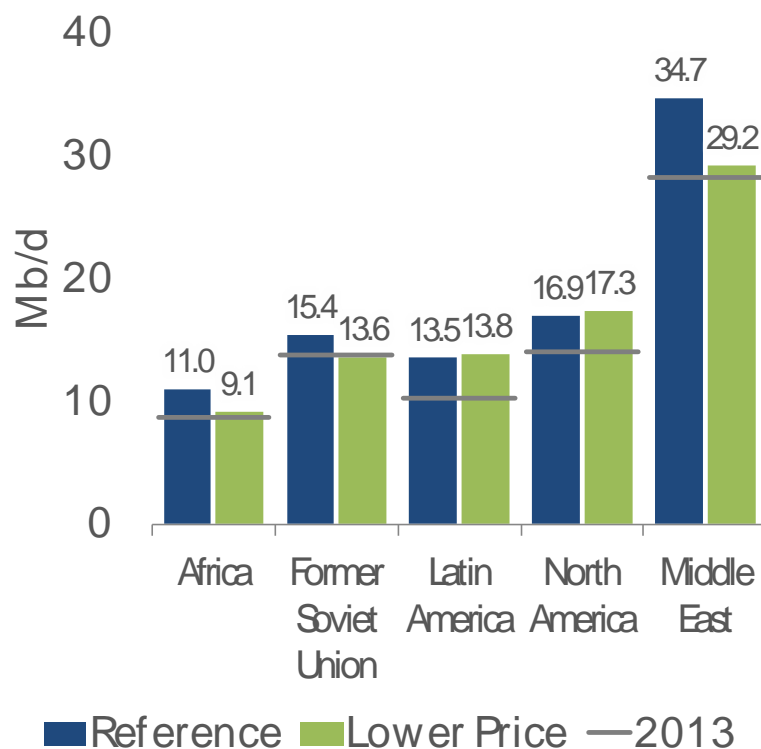


Note: Future prices are in \$2014.

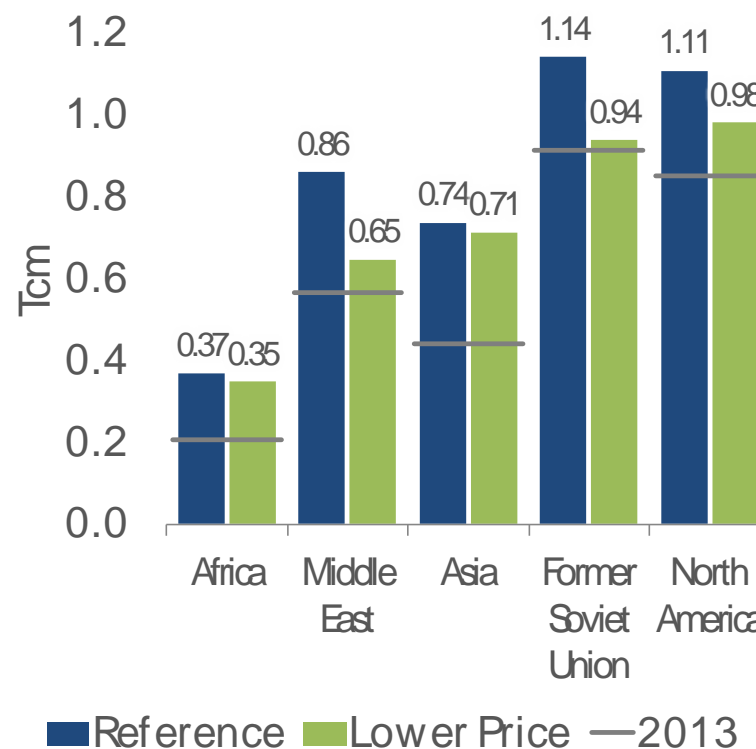
Easy supply-demand balance due to factors in supply and demand sides is assumed in the Lower Price Scenario. Real oil price in 2030 in the scenario is premised to be cheaper by 25% than in the Reference Scenario.

Depressed production in traditional exporting regions

Crude oil production in selected regions [2030]



Natural gas production in selected regions [2030]



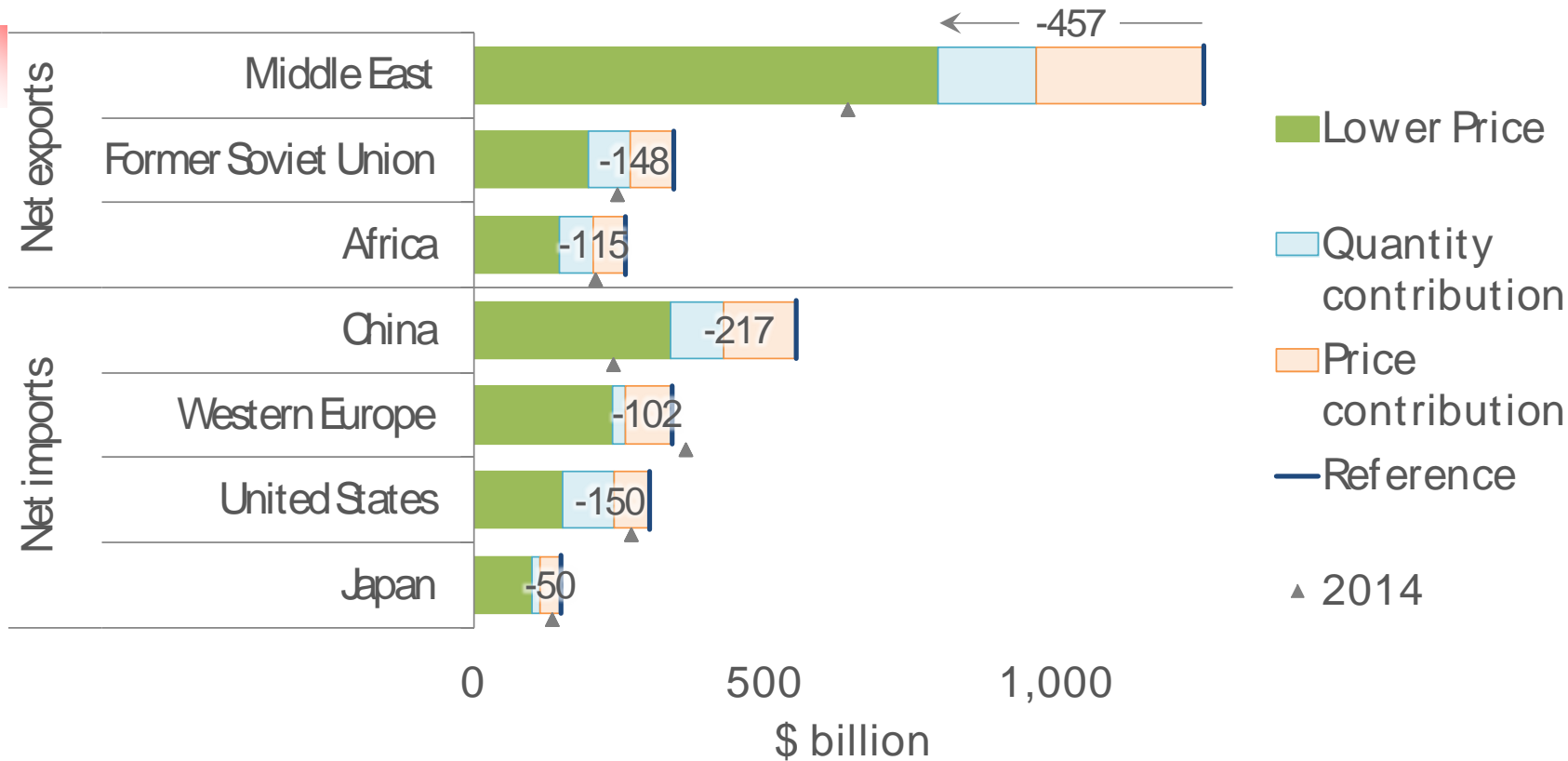
Global oil supply in 2030 is 96.5 Mb/d, increased by just 7.7 Mb/d from today, due to the assumed strong energy conservation and fuel switching to other energies.

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.



Low oil price impact on exporter and importer

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

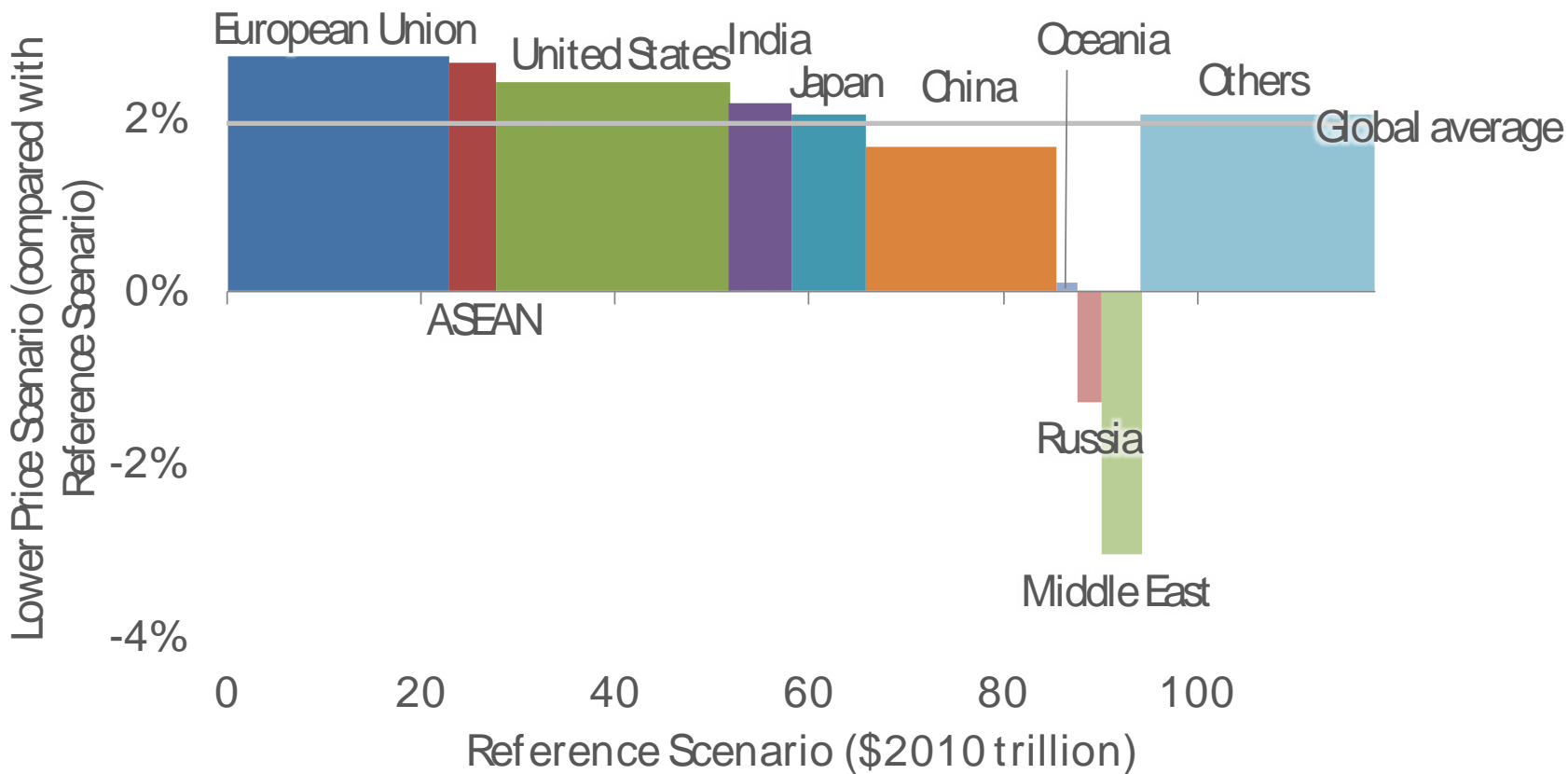


Oil saving, lower oil price and wider use of unconventional resources make international trade of crude oil* 36% less, to \$2.8 trillion from \$4.4 trillion, in the Reference Scenario. * Among the modelled 15 regions. Nominal value. China is the biggest winner in terms of saving of net import spending, acquiring \$217 billion. The United States follows with \$150 billion. Net export earning of the Middle East decreases by \$457 billion.



Lower oil price impact on global GDP

◆ Changes in real GDP [2030, compared with the Reference Scenario]

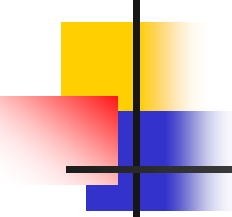


Lower prices and consumption of oil and natural gas vitalise importing countries' economies through less outflow of national welfare and improvement of real purchasing power. The global economy expands by 1.9%. The situation exerts downward pressure on oil producing countries in the Middle East and others, whose revenue depends heavily on energy exports.

Challenges for Japan's Energy Policy

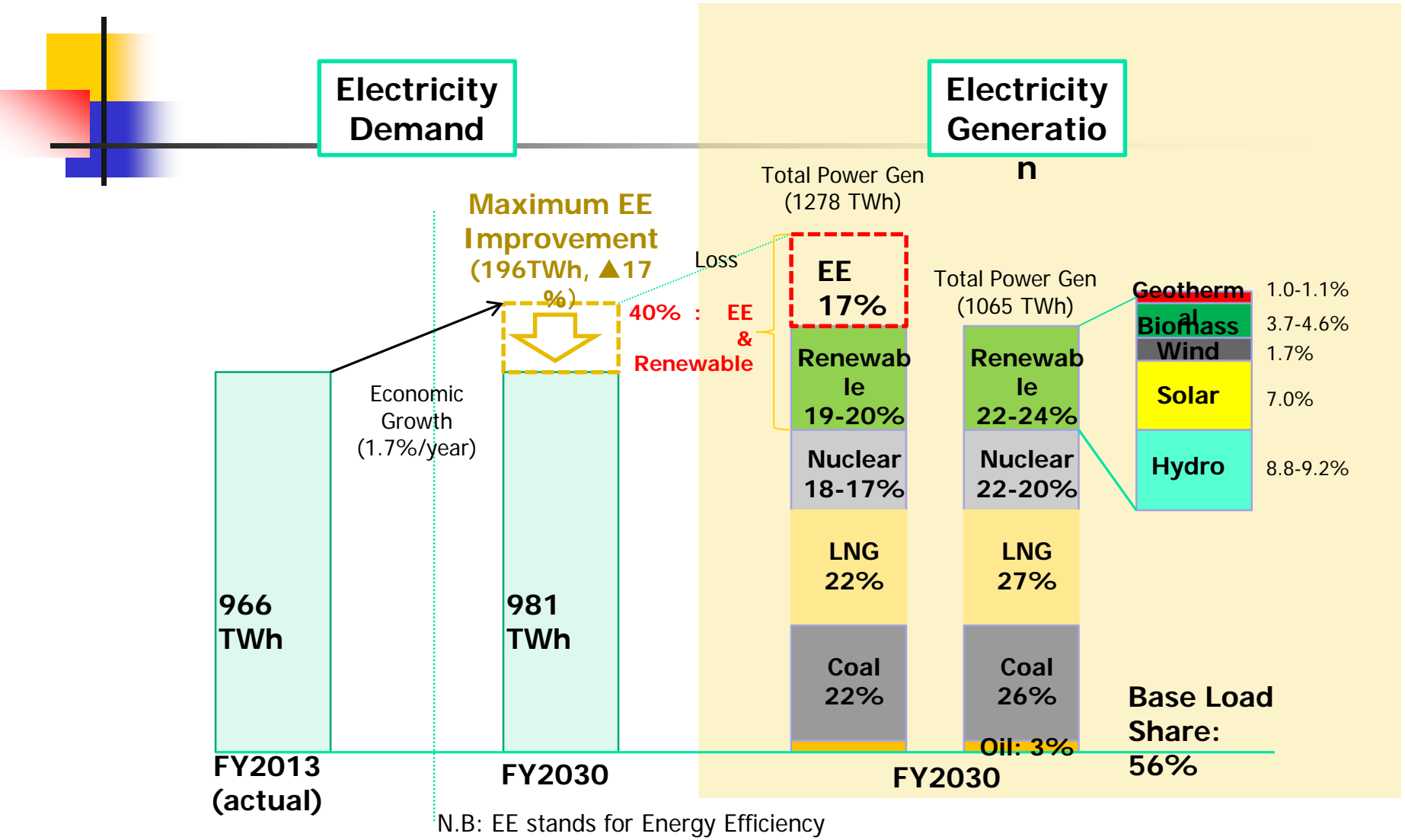
- **Re-start of nuclear power**
- **Best Energy Mix**
- **Energy Market Reform**
- **Security of Supply for Fossil Fuels**
- **GHG emission reduction target**

Principle of “Basic Energy Strategy”

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- A decorative graphic on the left side of the slide, featuring overlapping yellow, red, and blue squares with a black crosshair.
-
- To reduce dependence on Nuclear
 - To increase Renewable at maximum possible
 - To achieve Safety and 3Es (Energy Security, Economic Efficiency and Environment)
 - To realize balanced energy portfolio for 3Es



Strong Electricity Saving and Balanced Power Mix

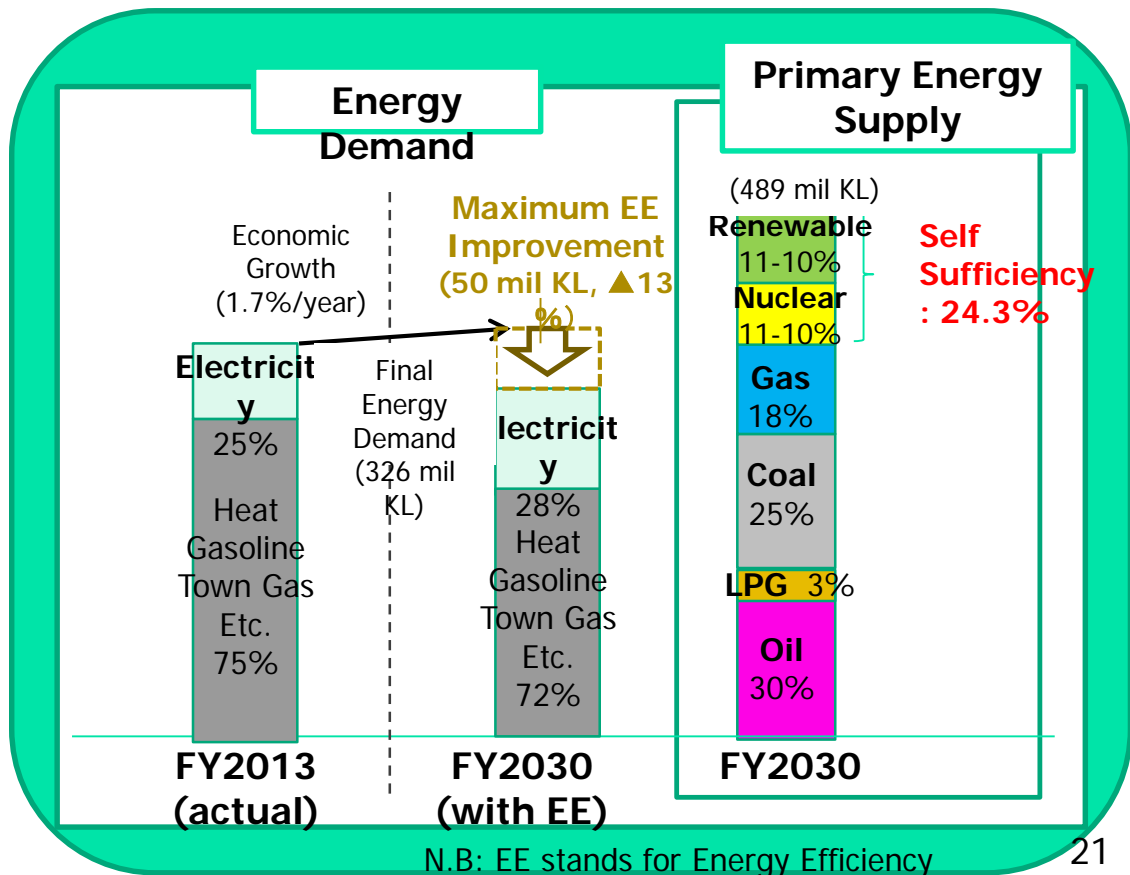
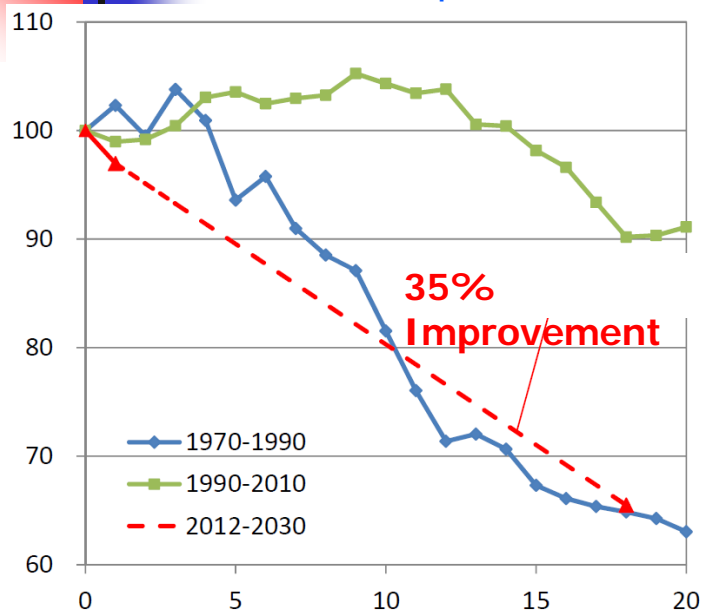


Source: from documents discussed at the "Long-term Energy Outlook Sub Committee", 10th Session (1st June 2015)

Energy Efficiency to be Improved Drastically

Energy Efficiency Improvement

(Final Consumption / real GDP)



Source: from documents discussed at the "Long-term Energy Outlook Sub Committee", 10th Session (1st June 2015)

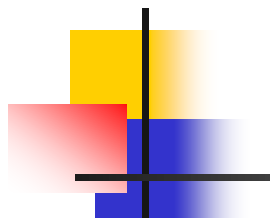
Japan's Primary Energy Demand Outlook

	FY2010		FY2013		FY2030	
	Million KLOE	%	Million KLOE	%	Million KLOE	%
Oil	212 (3.65MBD)	37	216 (3.72MBD)	40	145 (2.50MBD)	30
LPG	16	3	16	3	13	3
Coal	129	23	136	25	123	25
Gas	110	19	131	24	92	19
Nuclear	64	11	2	0.8	48~51	10~11
Renewable	43	8	41	8	64~67	13~14
Total	572	100	542	100	489	100

Comparison of GHG Reduction Target

	vs 1990	vs 2005	vs 2013
Japan	▲ 18.0% (2030)	▲ 25.4% (2030)	▲ 26.0% (2030)
US	▲ 14~16% (2025)	▲ 26~28% (2025)	▲ 18~21% (2025)
EU	▲ 40% (2030)	▲ 34% (2030)	▲ 24% (2030)

Conclusion

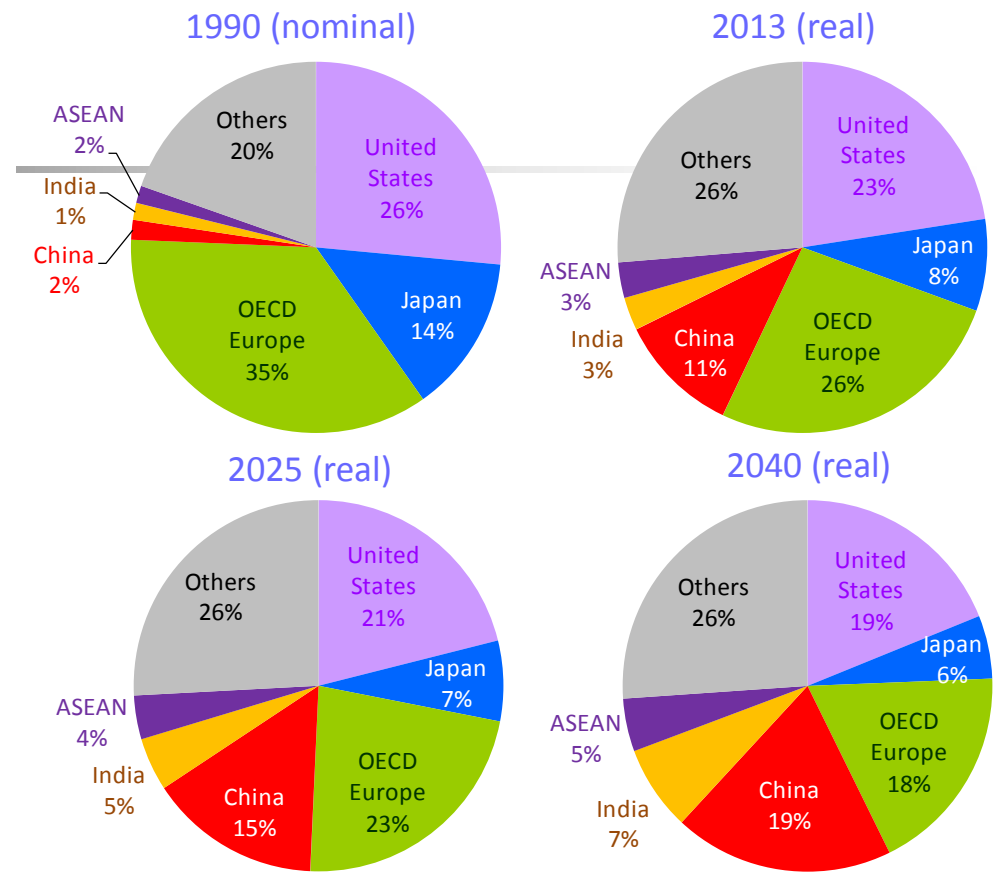
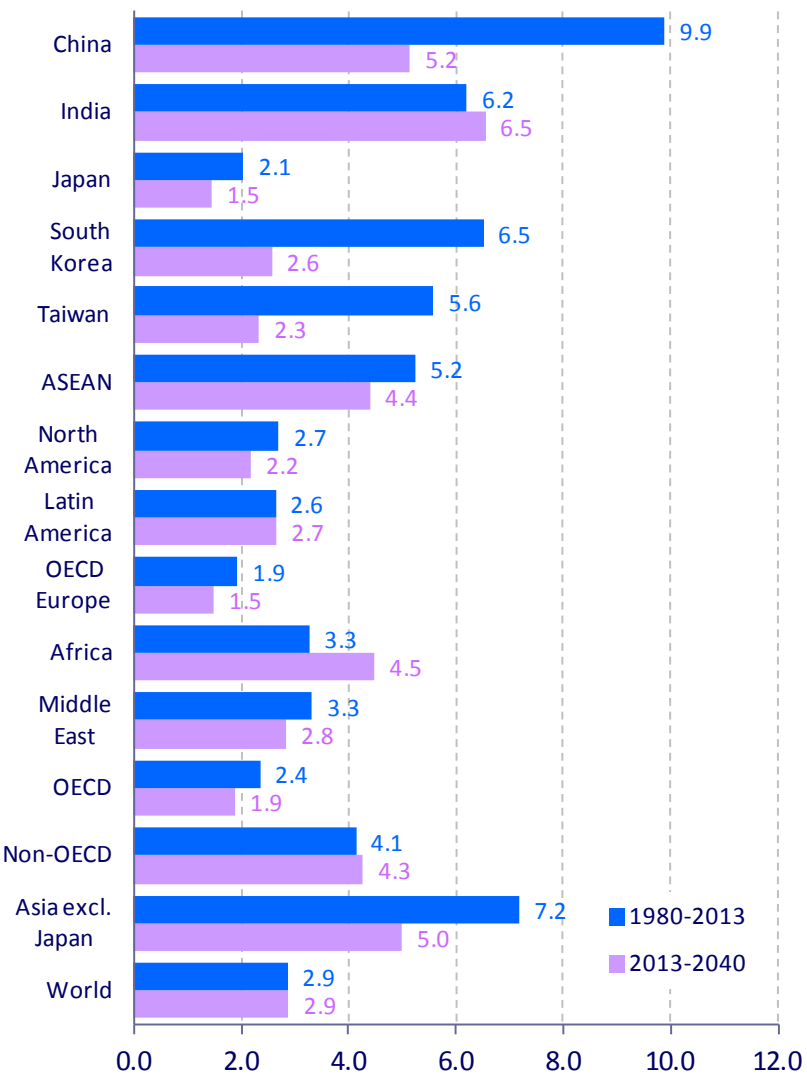
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- **Global energy market is characterized by over-supply situation in the short-term. But many uncertainties remain in the long run.**
 - **Center of gravity in global energy market shifts to Asia.**
 - **Fossil fuels will remain as a dominant source.**
 - **Advanced technology will change the energy future.**
 - **Climate change policy has very important implications on the world energy future.**
 - **Lower oil price will affect global energy and economy.**
 - **Comprehensive review for energy policy underway in Japan (“3Es” plus “Safety” as a basic principle)**



Appendix 1. Major Assumptions: Economic Growth



Note: Real values are in 2010 USD



Average annual growth rate, %

Source: IEEJ, "Asia/World Energy Outlook 2015"

Appendix 2. 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	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	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	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	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

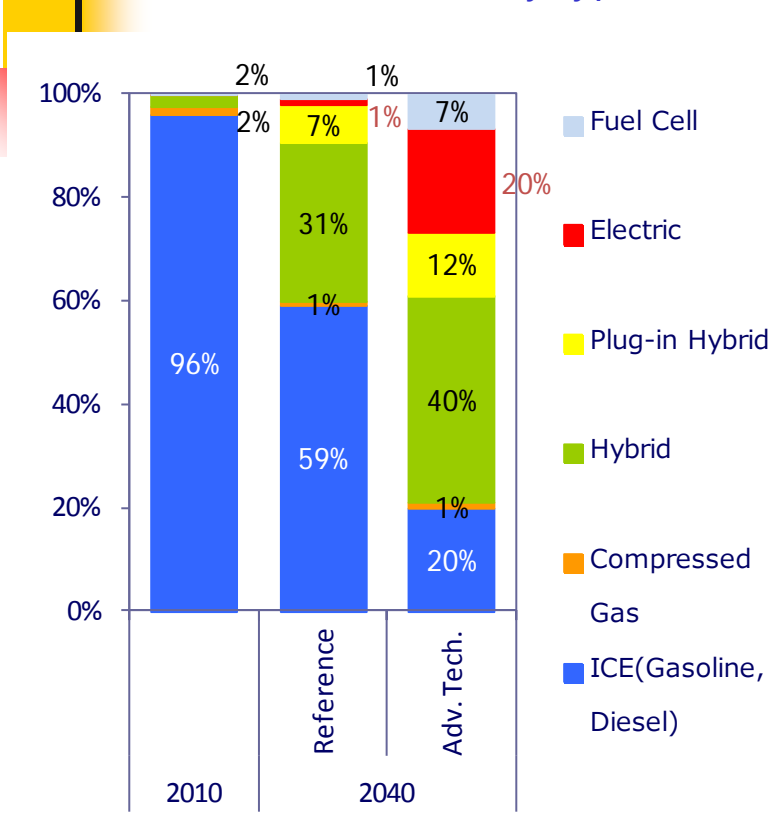
- Prices are for calendar years. Real prices are in 2014 dollars.
- Japan's energy prices are on a CIF import basis.

CIF import prices for Japan

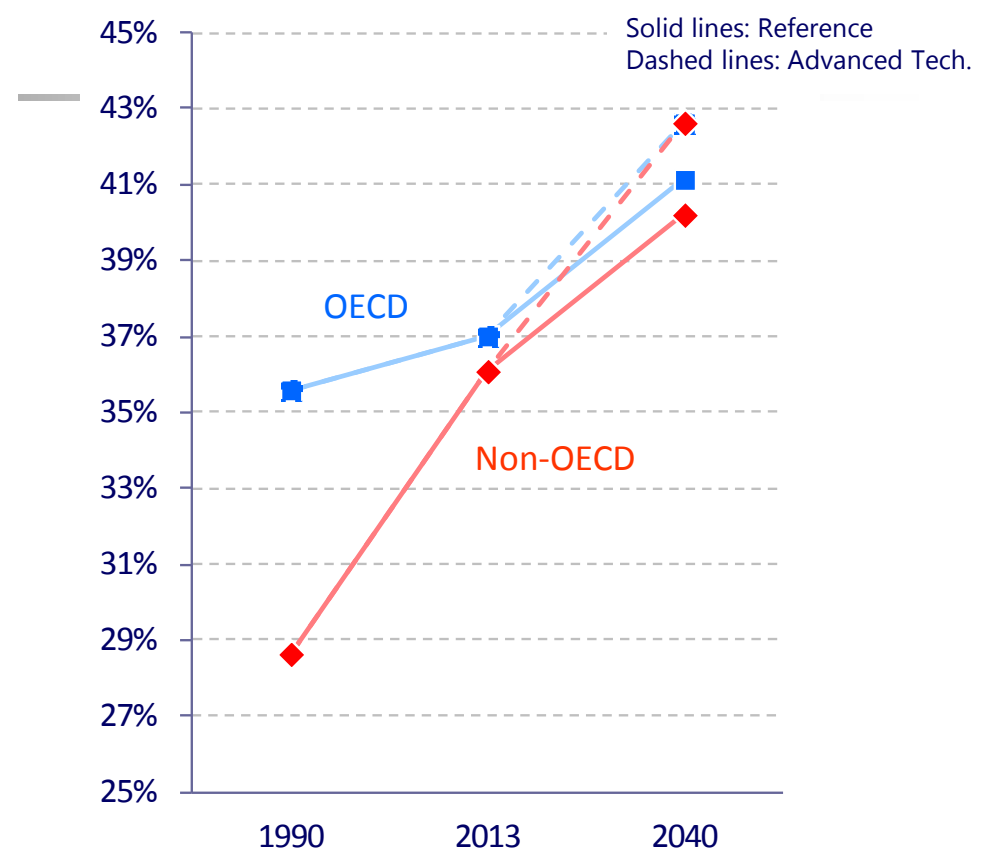


Appendix 3. Assumptions for the Advanced Technologies Scenario

The share of vehicle sales by type (world)

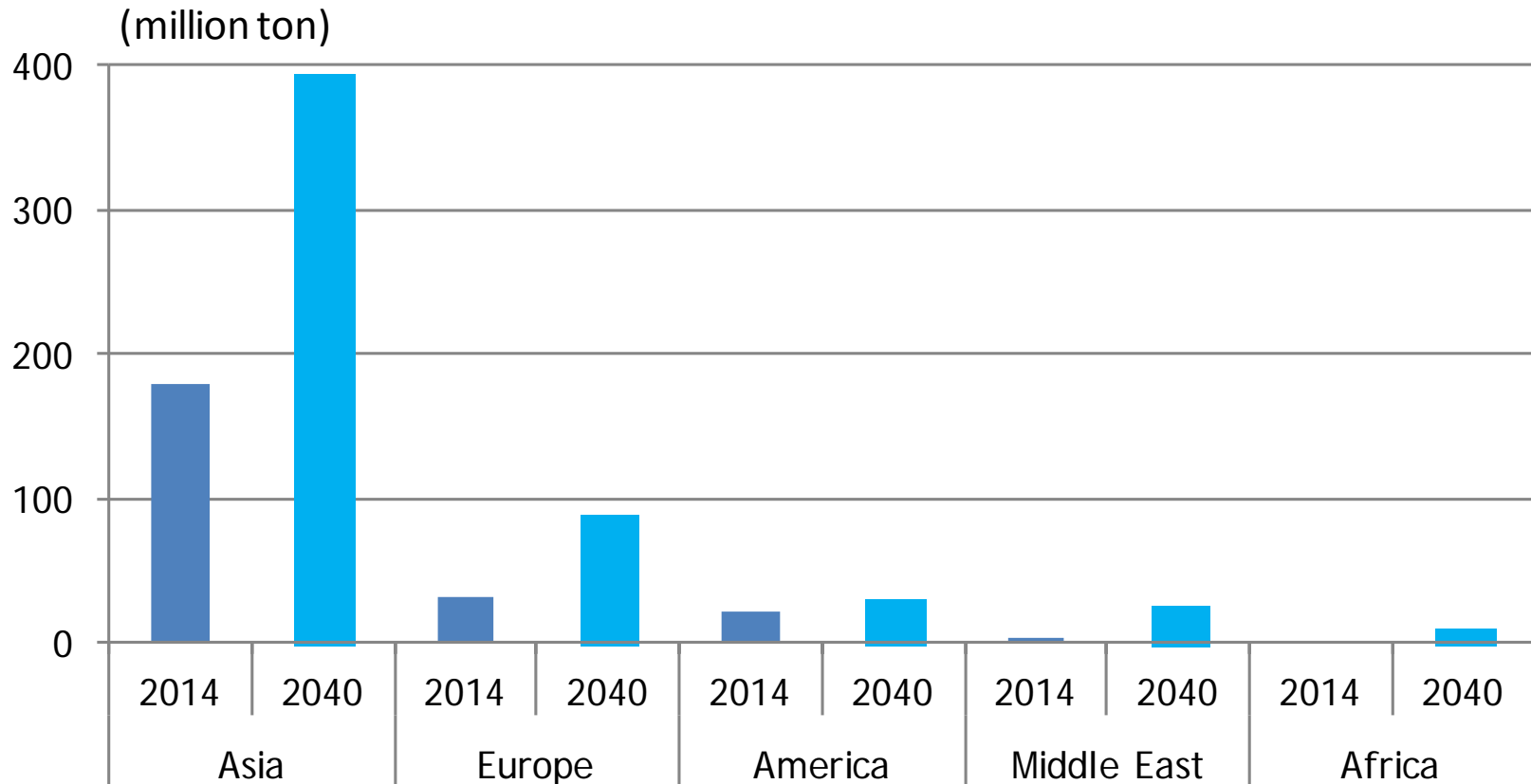


Thermal efficiencies of coal-fired power plants



- In the Advanced Technologies Scenario for the transport sector, clean energy vehicles diffuse drastically and fuel efficiency is improved. In the power sector, low carbon technology diffuses and highly efficient fossil-fired power plant technology are introduced.
- In the industrial, residential and commercial sectors, the technologies that become available in the near future are heavily introduced.

Appendix 4. LNG imports Outlook Reference Scenario



- World LNG demand expands from 239 million tons in 2014 to 547 Mt in 2040 (2.3 times).
- Asia's LNG demand increases by 214 Mt, accounting for about 70% of the world's LNG demand growth, whereas the growth in Europe (56 Mt) accounts for around 20%. LNG import from North America to Latin America increases by 6 Mt.
- LNG supply capacity is sufficient to meet demand if new LNG projects starts on schedule in the future.

Appendix 5. Instability in the Middle East

Terrorist Attacks In Paris

Uncertainty over Middle East Peace issues

Gaza crisis

Impacts of "Arab Spring"

Growing Anti US sentiments in Arab and Islam society

Iraqi situations after the war

Immigrants to Europe

Russia-Turkey Tension

Syria, Yemen, Egypt...

Domestic challenges for existing rulers and regimes

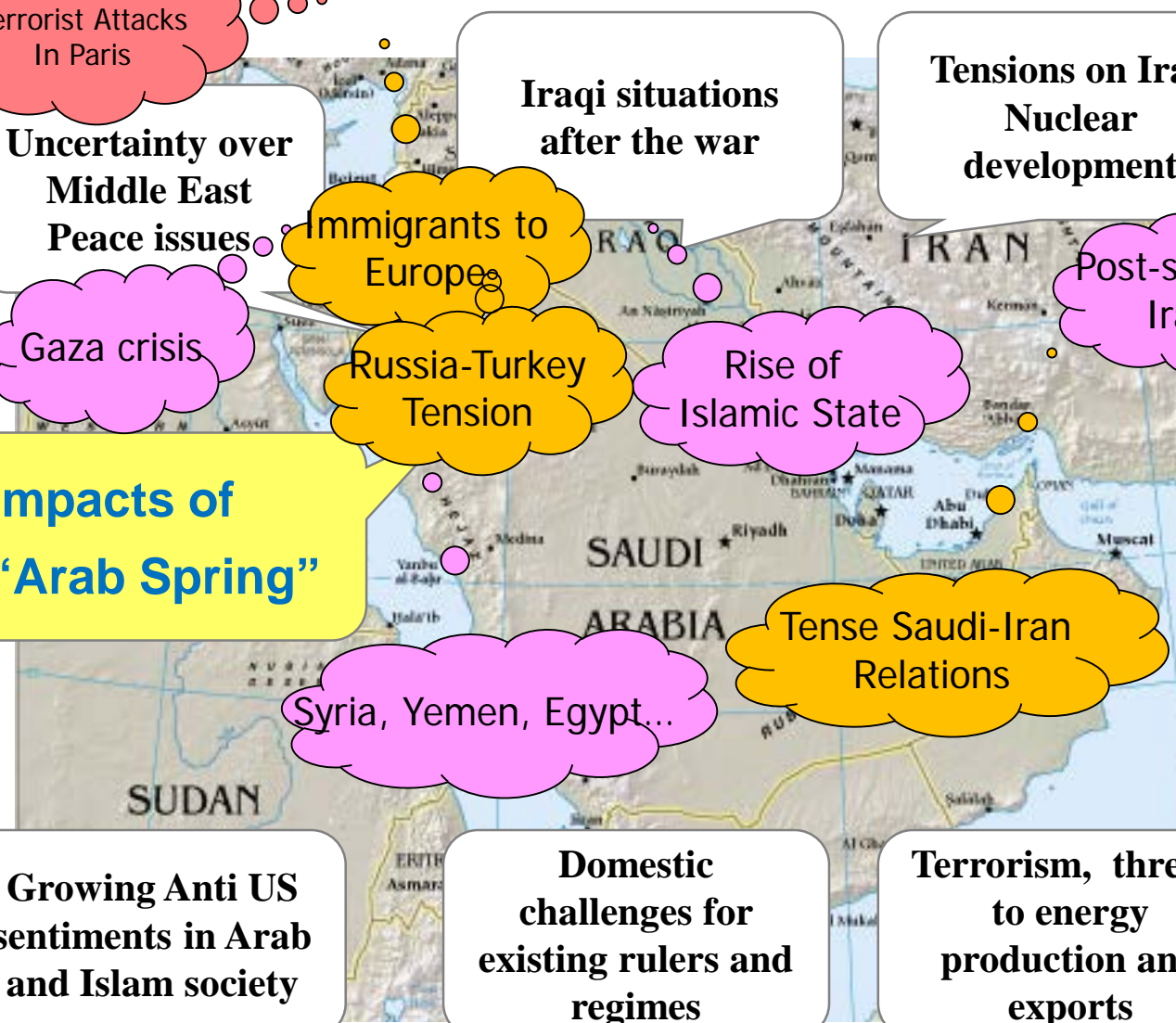
Tensions on Iran Nuclear development

Post-sanction Iran?

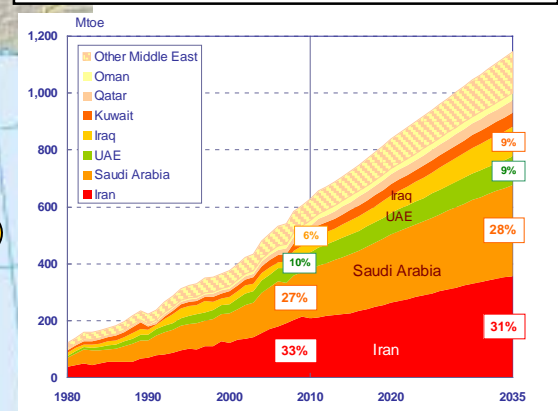
Tense Saudi-Iran Relations

Terrorism, threats to energy production and exports

Rising energy demand and its impacts

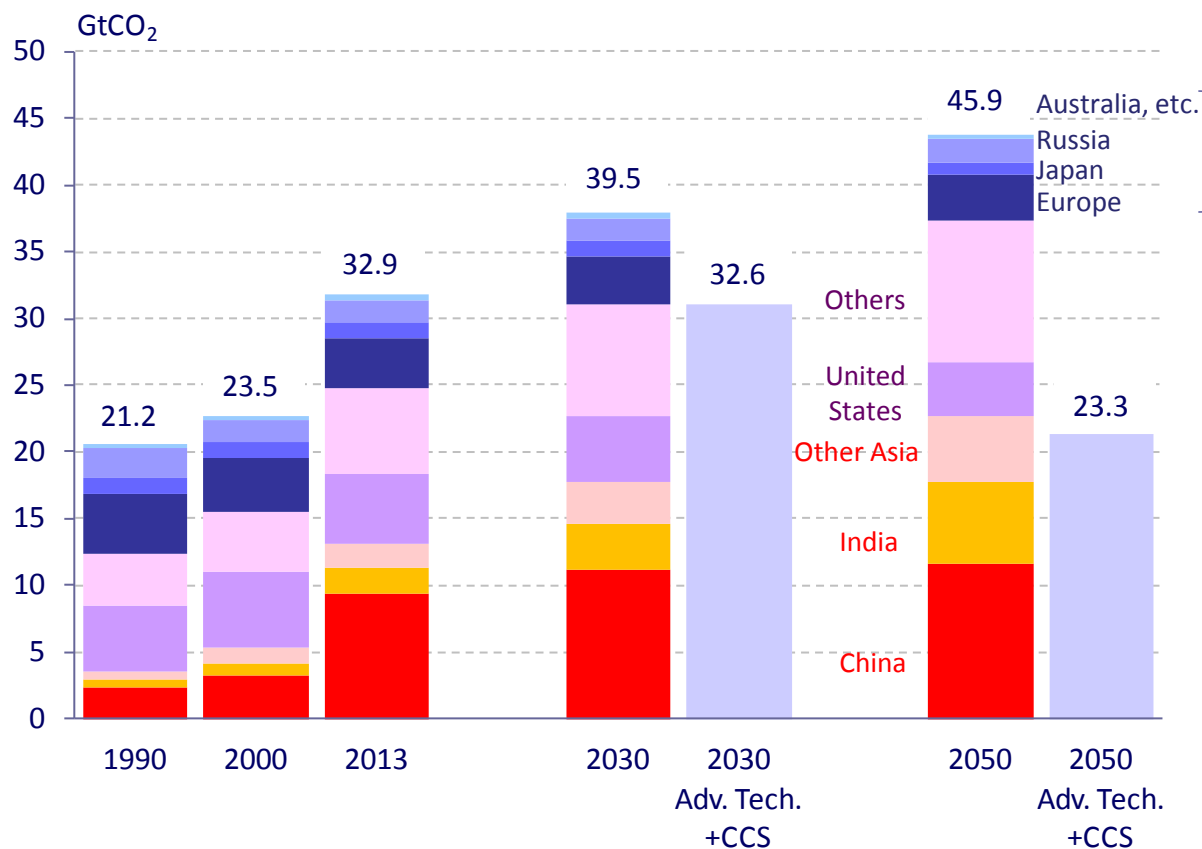


Outlook for energy demand in Middle East



Appendix 6. CO₂ Emissions by region

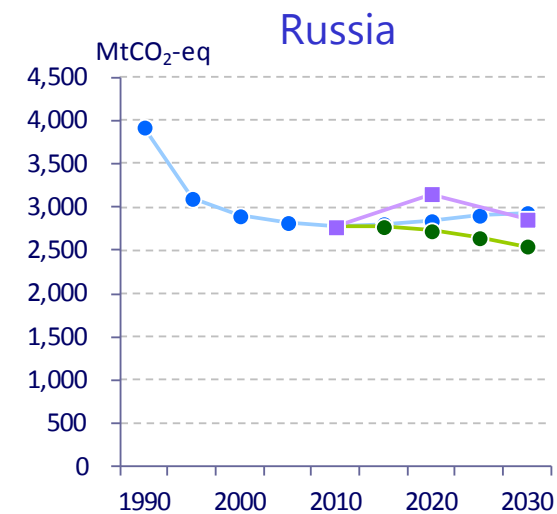
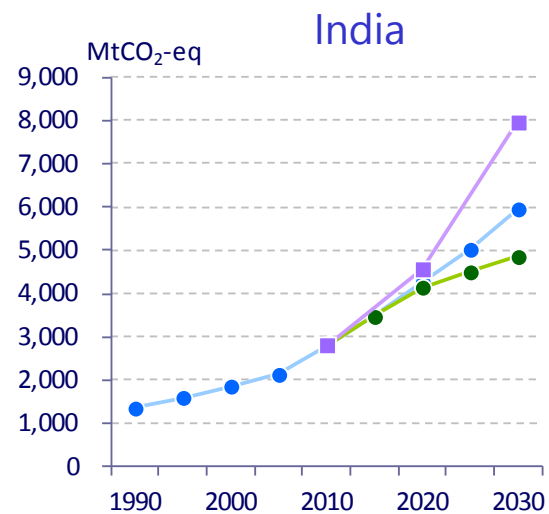
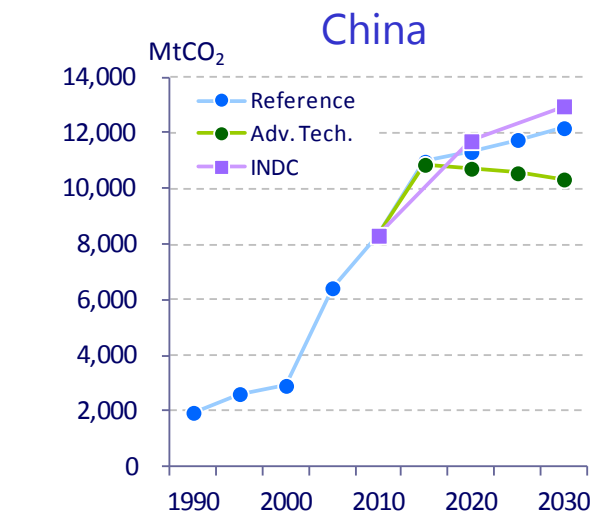
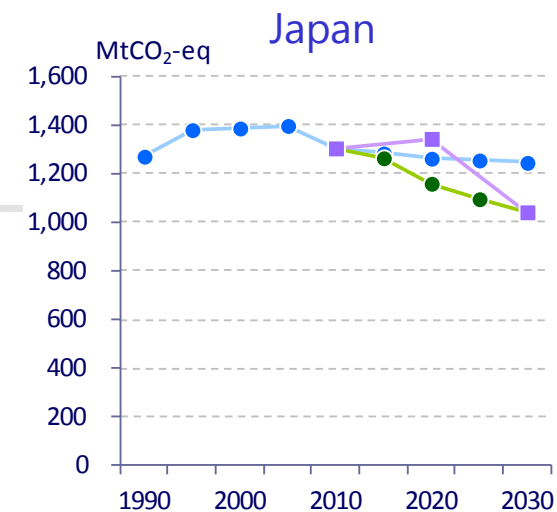
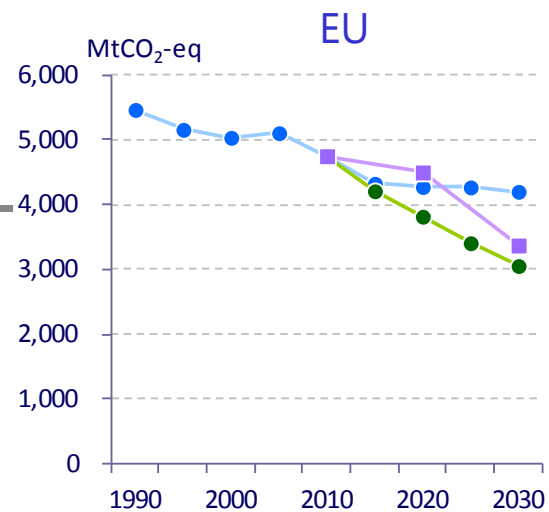
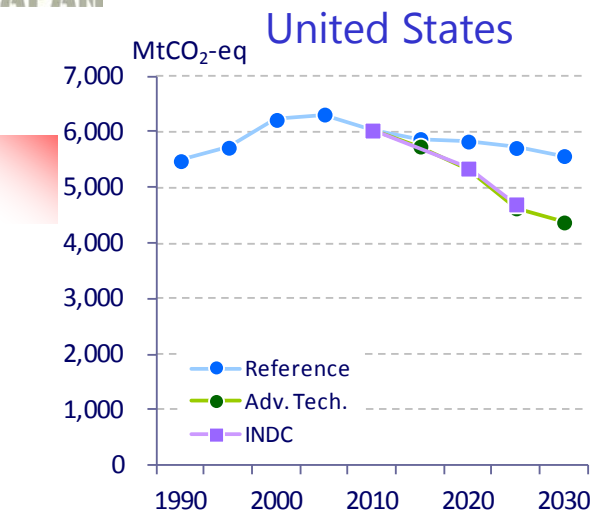
Note: Total figures include international bunkers.



- Global energy-related CO₂ emissions will increase 1.4 times from 2013 to 2050. The expansion is especially rapid in India and other Asian countries, as well as Africa, the Middle East and Latin America.
- The share of the ANNEX I countries with reduction obligations under the Kyoto Protocol was 40% in 1990. It declined to 22% in 2013, and will decline further to 15% by 2050.



Appendix 7. INDCs and IEEJ Outlook by country



- The INDC targets of the United States and Japan are as ambitious as the Advanced Technologies Scenario. The target of EU is also positioned near the ATS.
- The targets of China and India exceed the Reference Scenario in terms of CO₂/GHG emissions.

Note: Japan's 2020 target does not include reduction by nuclear power. China's target is for CO₂, while others are for GHG.

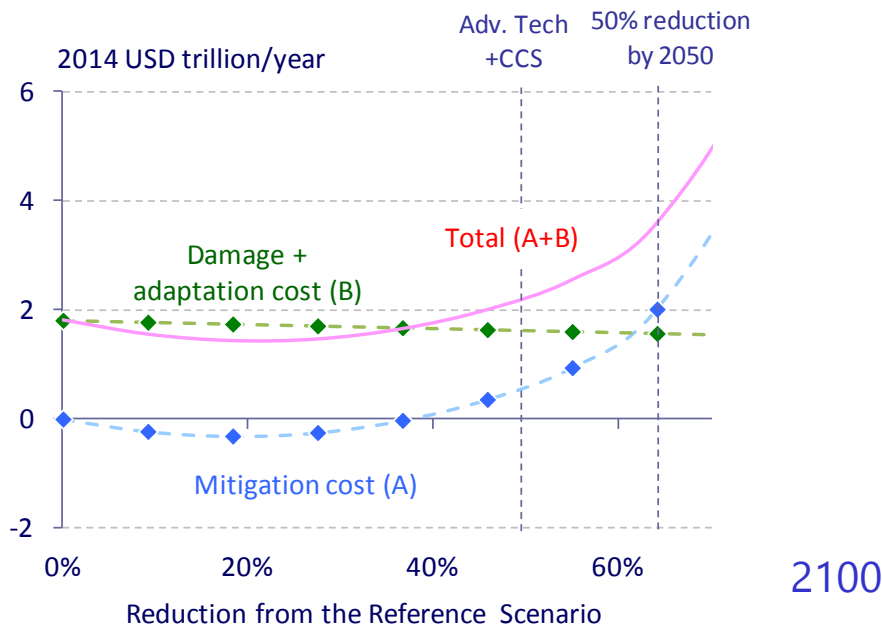
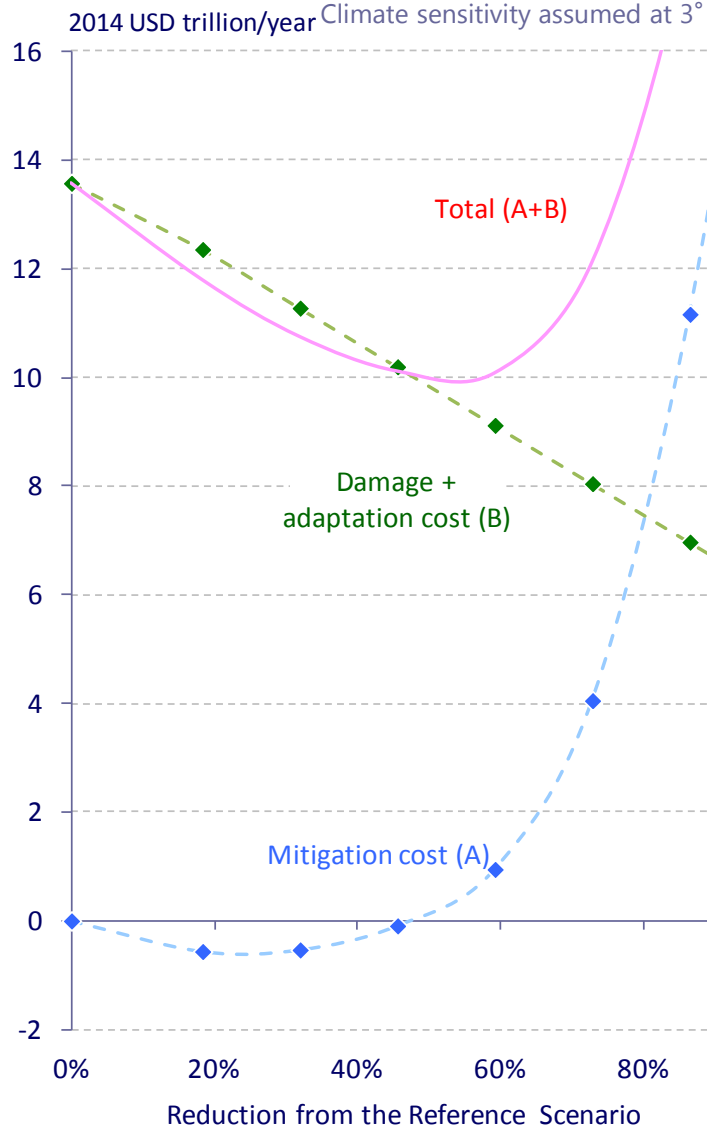


Appendix 8. Mitigation vs. adaptation and damage



- In 2050 the temperature rise is relatively small (less than 2° C from the latter half of the 19th century), resulting in smaller damage.
- CO₂ 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.

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



2050

2100