# A Japanese View on the World Energy Future

## Public Lecture at UNITEN

**December 7th, 2015**

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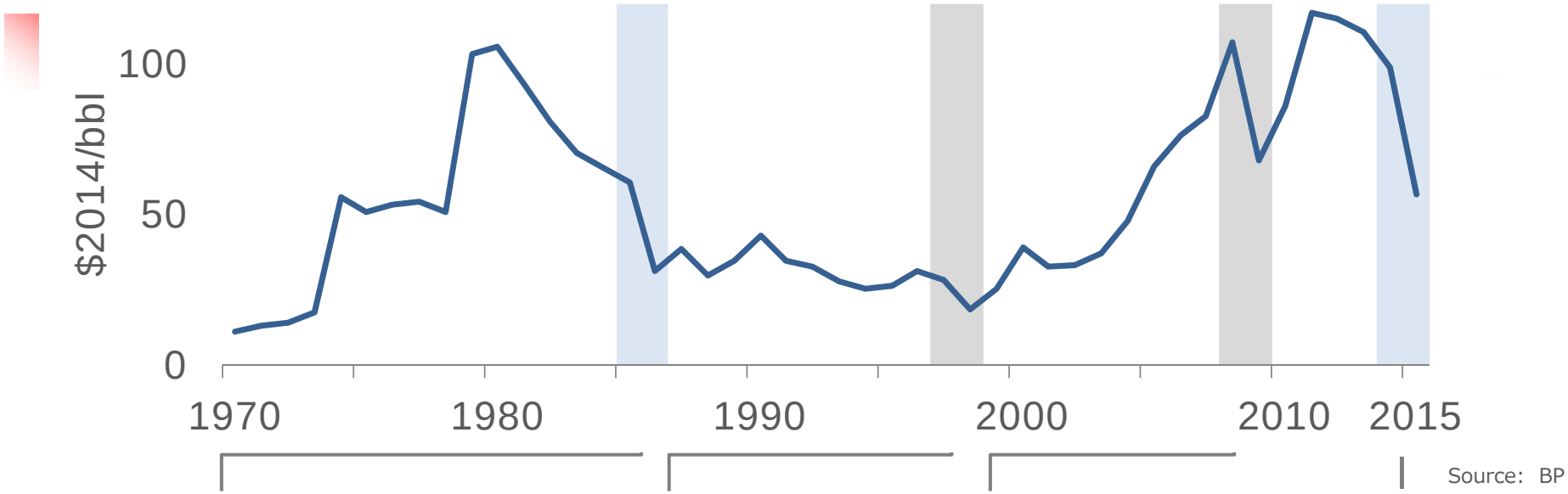
# Emerging landscape with regard to global energy market

- 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

# "History doesn't repeat itself, but it does rhyme"

Mark Twain

## ❖ Oil price




Source: BP

- Decreases in demand and increases in supply by non-OPEC countries 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 on the Asian financial crisis
- Expansion of OPEC production quota and excess production by the members over their quota

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

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

Source: IEEJ, "Asia/World Energy Outlook 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.

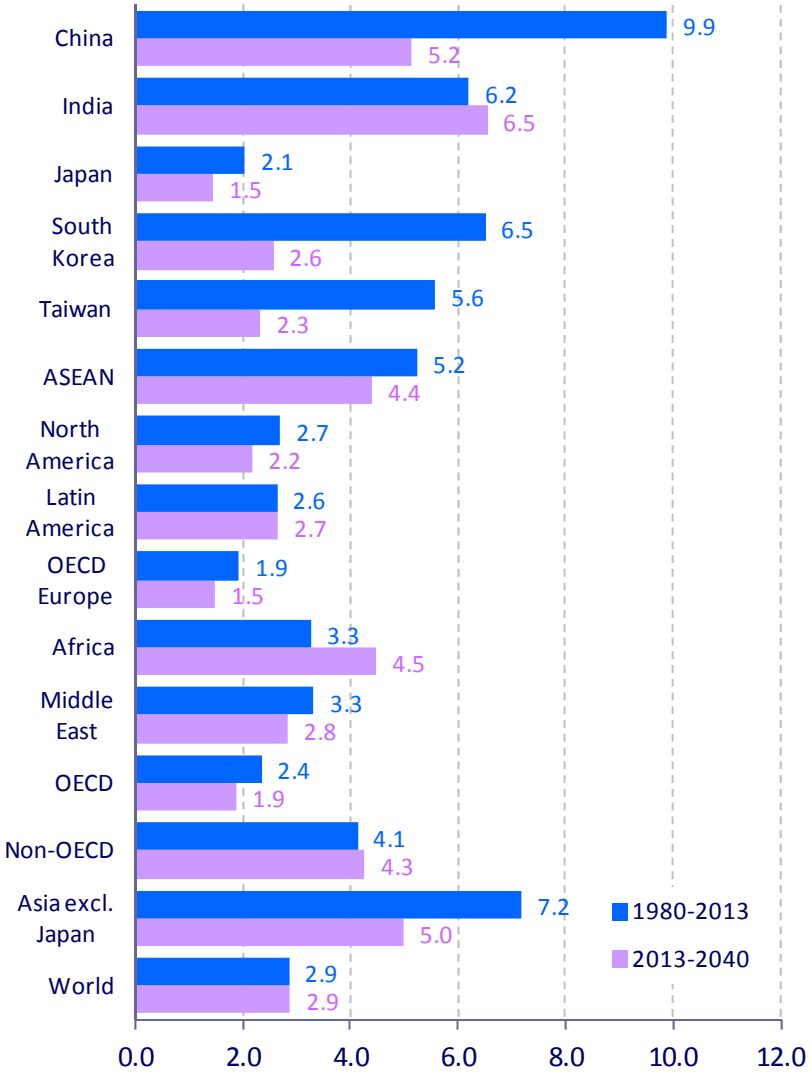
## Lower Price Scenario

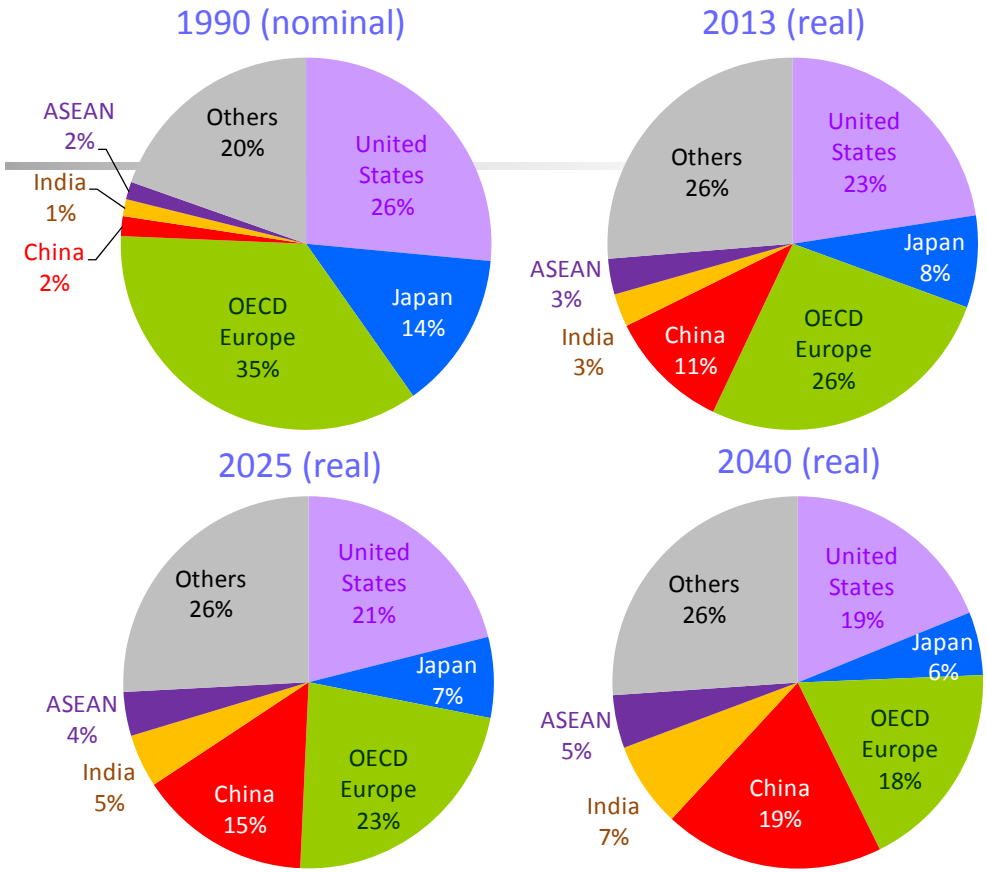
In this scenario, it is assumed that energy savings will be pursued as stringently as in the Advanced Technologies Scenario, while assuming large increases in unconventional oil and natural gas production, resulting in considerable relaxation of supply and demand.

Source: IEEJ, “Asia/World Energy Outlook 2015”

# Major Assumptions: Economic Growth

Note: Real values are in 2010 USD




Source: IEEJ, “Asia/World Energy Outlook 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.

CIF import prices for Japan

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

# 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.

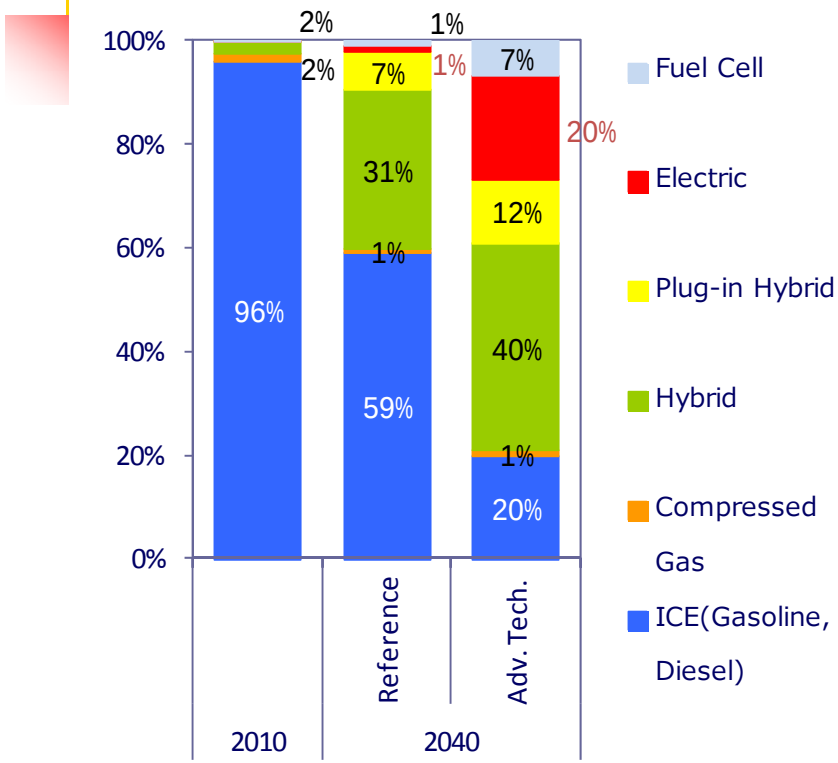
### ■ CCS

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).

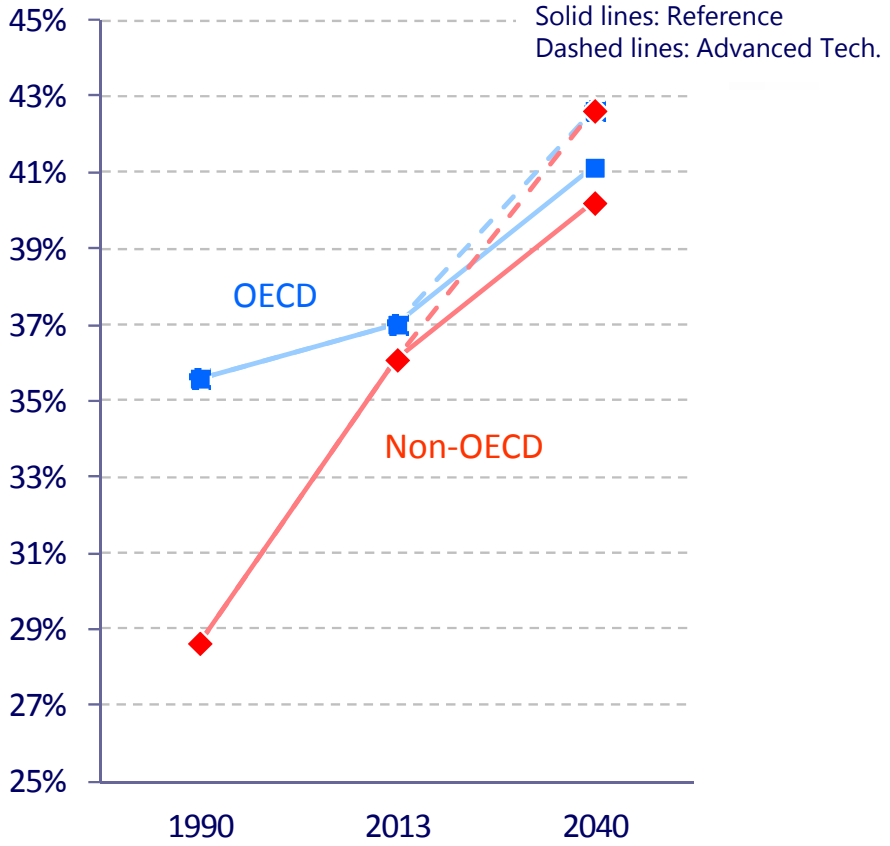
Source: IEEJ, “Asia/World Energy Outlook 2015”

# Assumptions for the Advanced Technologies Scenario (Examples)

## The share of vehicle sales by type (world)



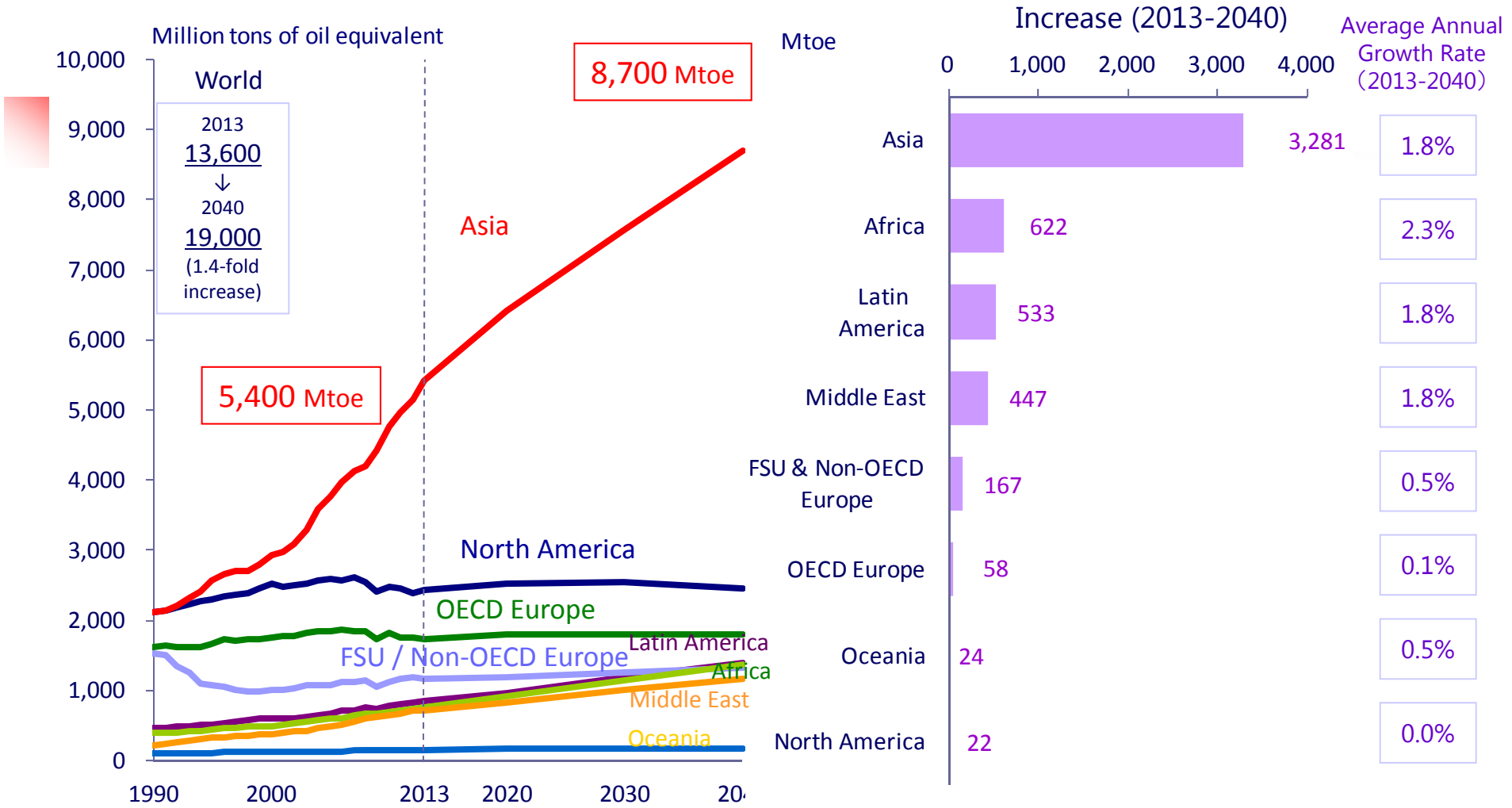

## Thermal efficiencies of coal-fired power plants




- 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.

Source: IEEJ, “Asia/World Energy Outlook 2015”

# Primary Energy Demand Outlook Reference Scenario

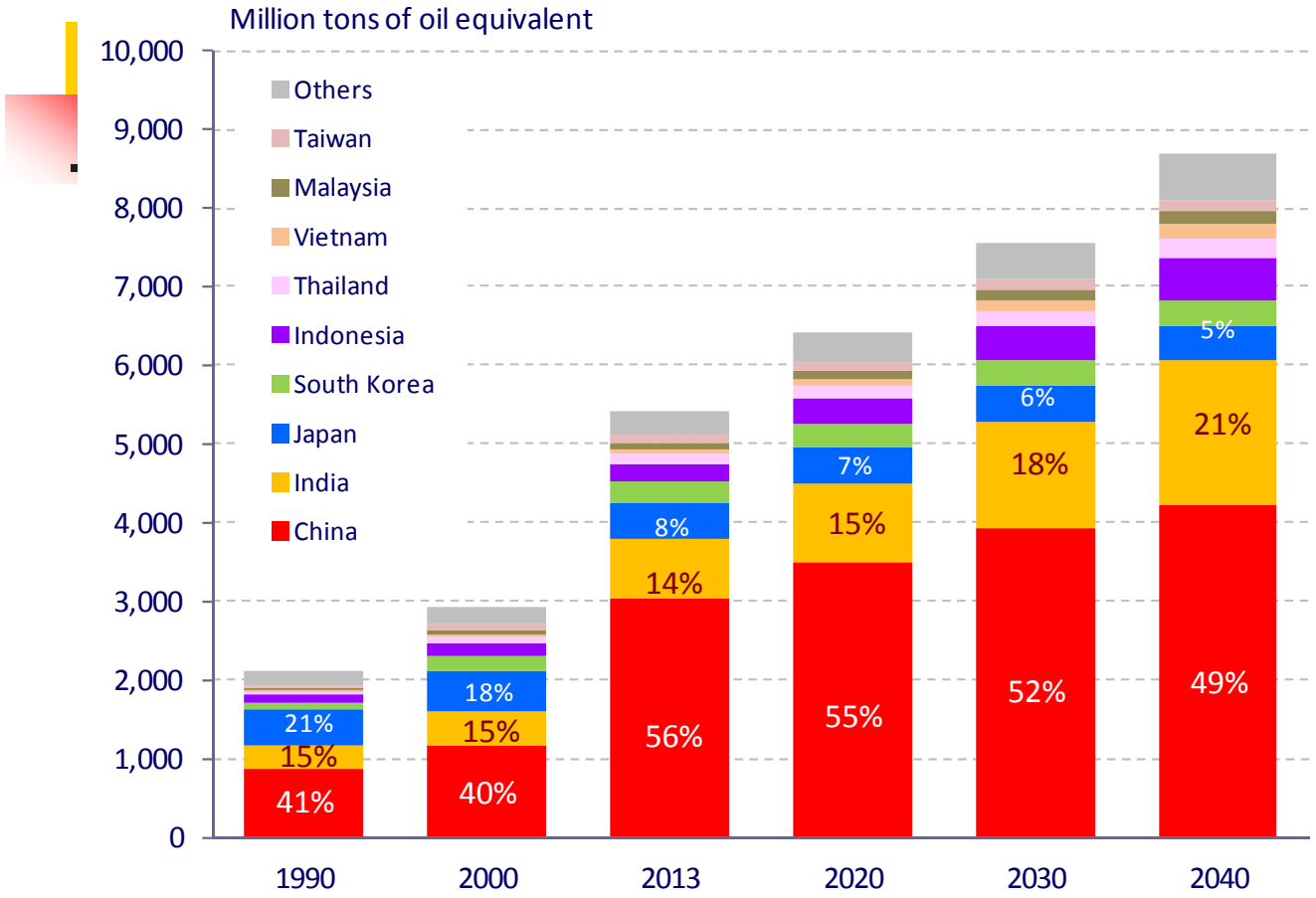



- Under the steady economic growth assumption, Asian energy consumption in 2040 increases 1.6-fold from the present level (from 5.4 billion tons in 2013 to 8.7 billion tons in 2040).
- Non-OECD countries account for about 90% of global energy consumption increase between 2013 and 2040.

Source: IEEJ, “Asia/World Energy Outlook 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.)

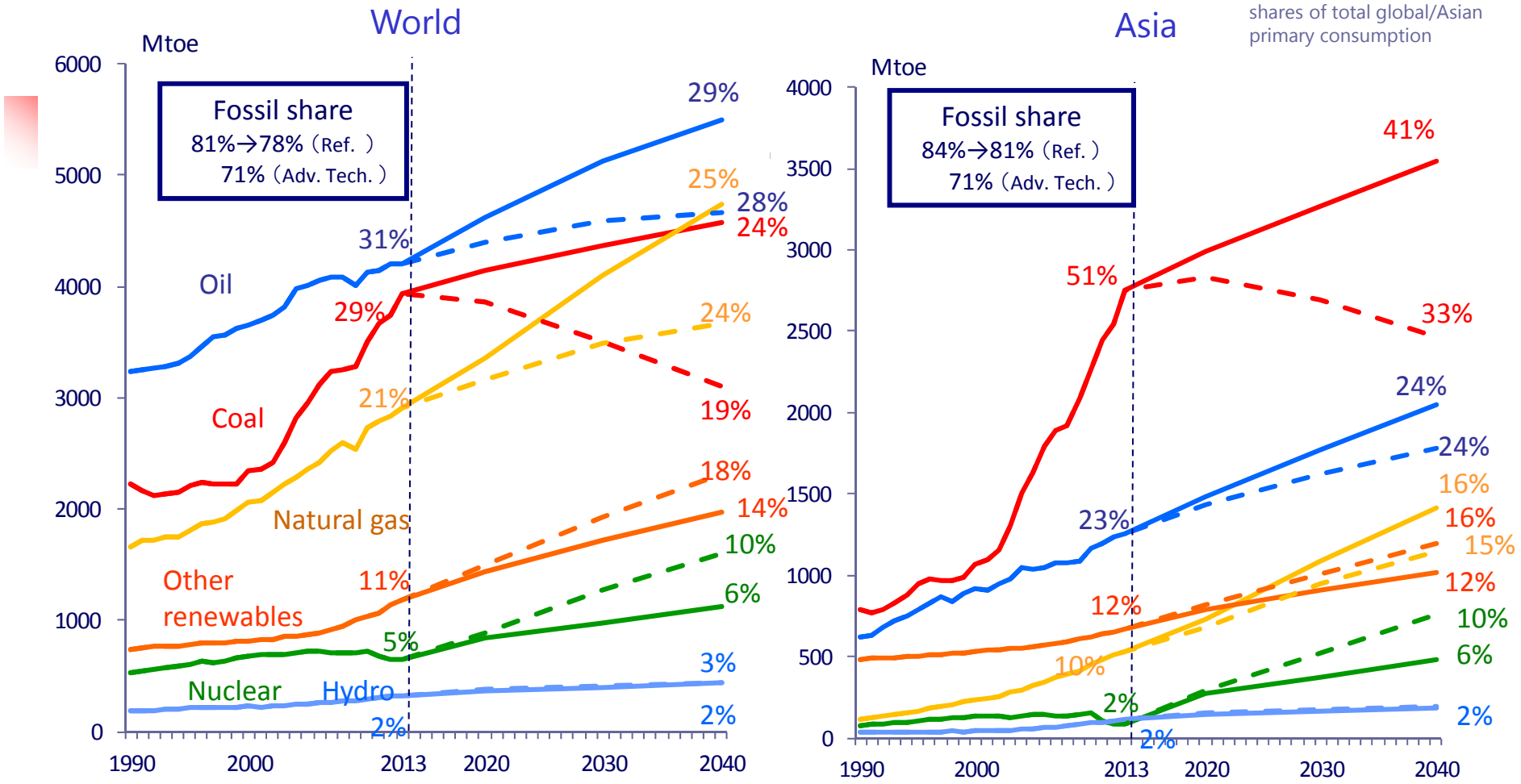
- Energy demand in China and India increase rapidly in line with economic growth. Their share of Asian energy demand expands 70% in 2040.
- Japan's energy consumption declines as a result of progress in energy efficiency combined with a maturing economy and a decreasing population. Its share of Asian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

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

# Primary Energy Demand by Source

Solid lines: Reference
Dashed lines: Adv. Tech.

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

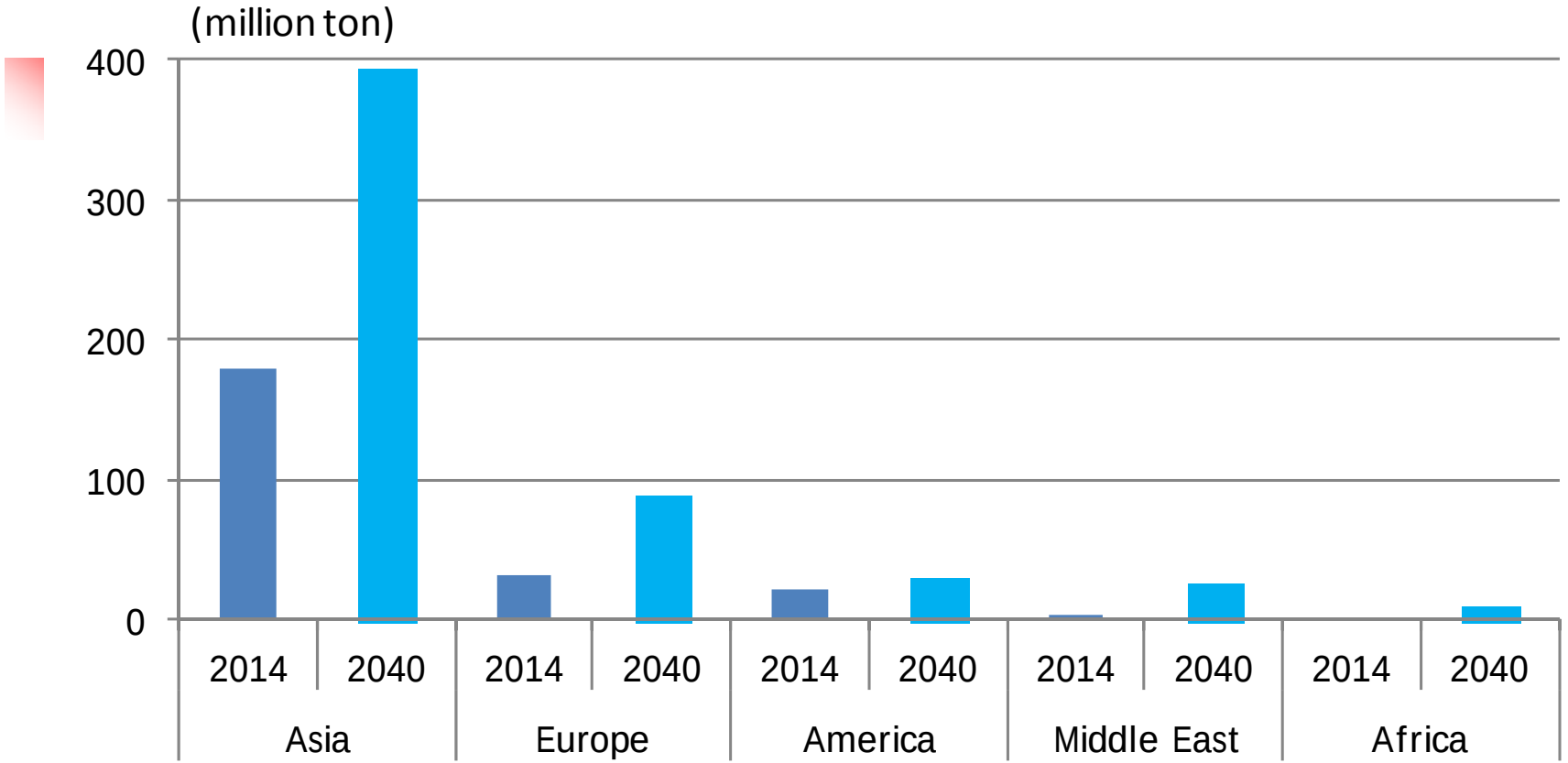



- In both the Reference and Advanced Technologies Scenarios, oil continues to be the largest share of primary energy consumption and remains a major energy source up to 2040.
- In Asia, coal remains the largest share among energy sources. In the Advanced Technologies Scenario, coal consumption declines 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.

Source: IEEJ, “Asia/World Energy Outlook 2015”

# LNG imports Outlook

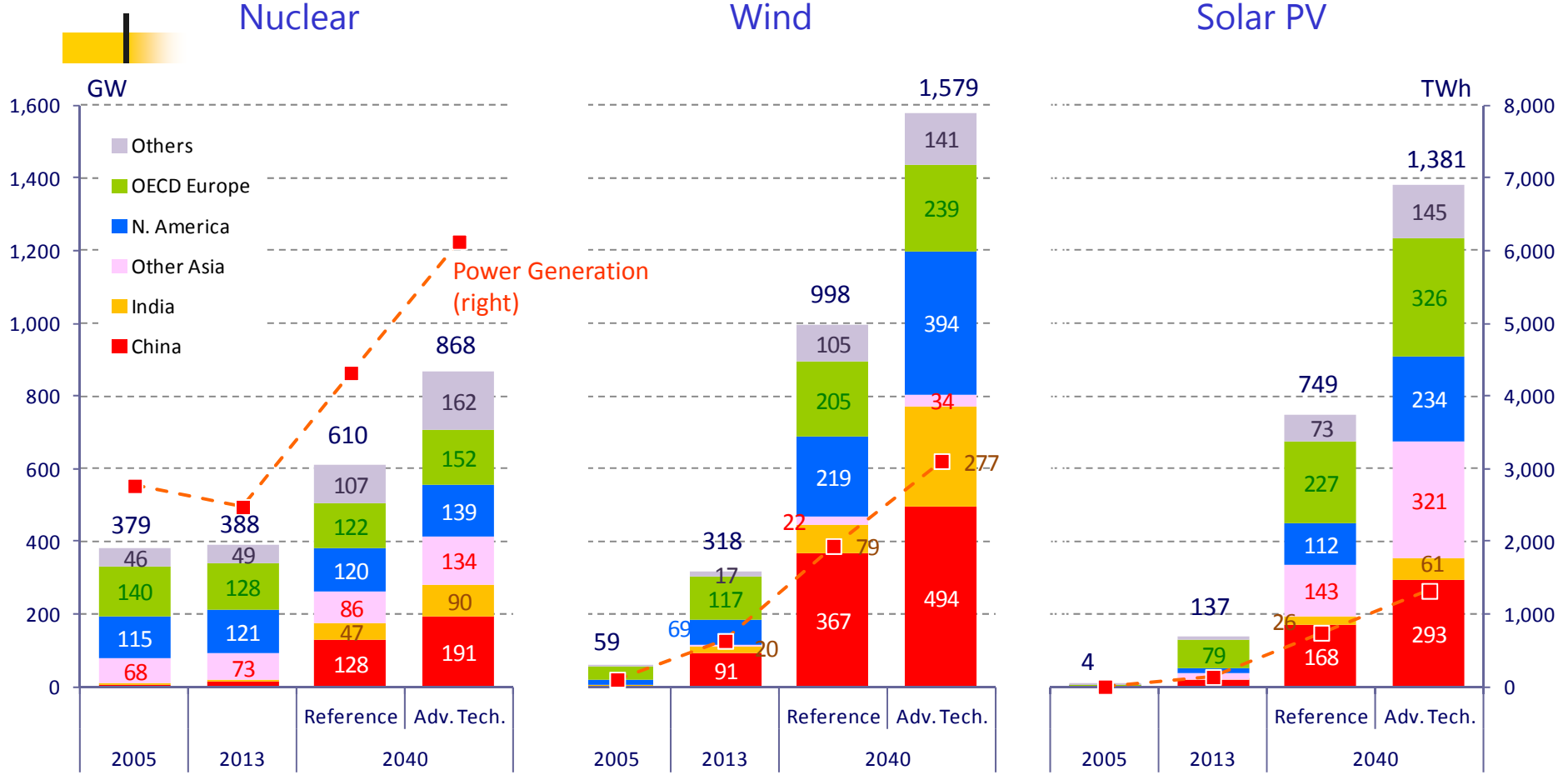
Reference Scenario




- 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.

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

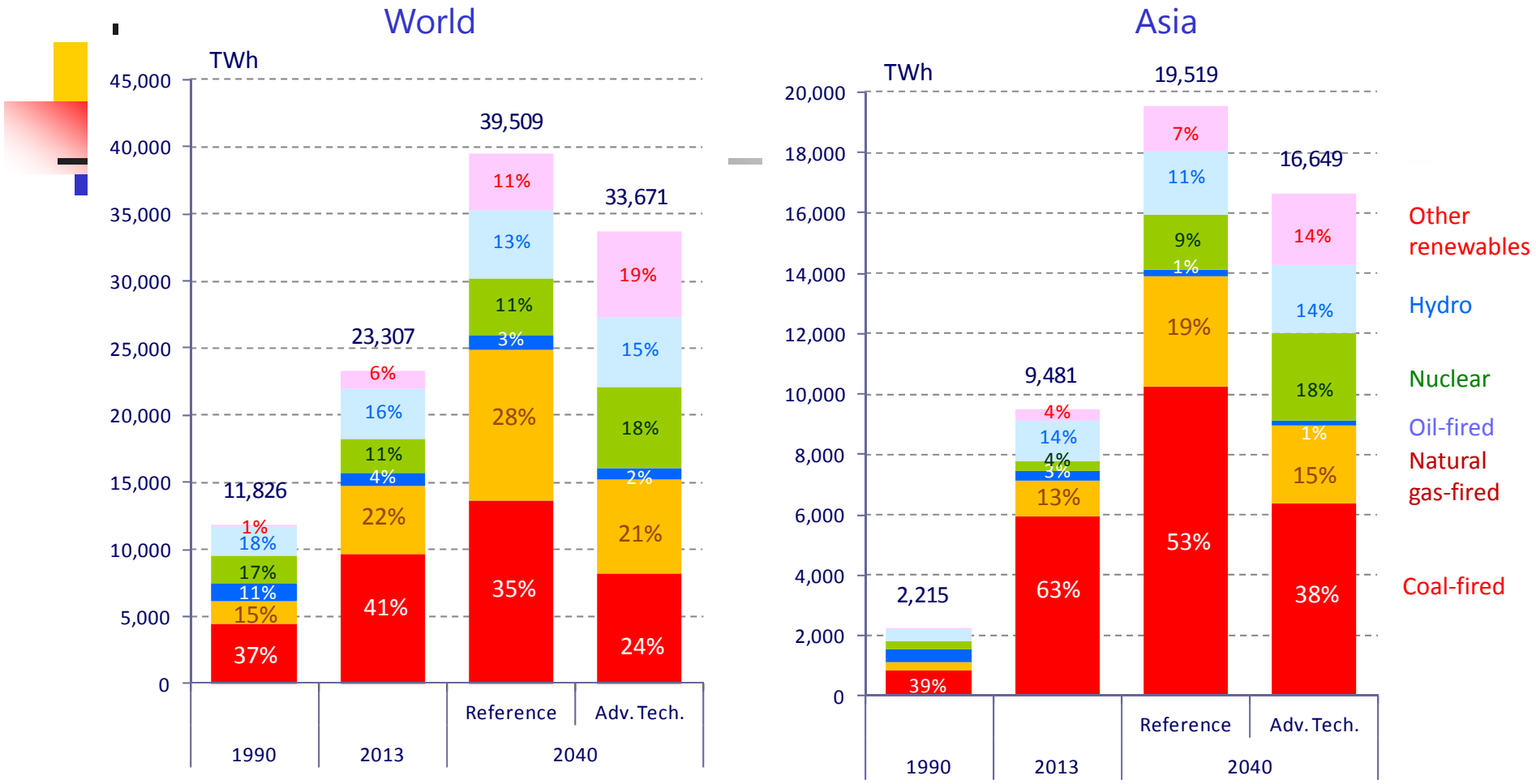
# Outlook for nuclear and renewable power capacities




- 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.

Source: IEEJ, “Asia/World Energy Outlook 2015”

# Power generation mix in 2040

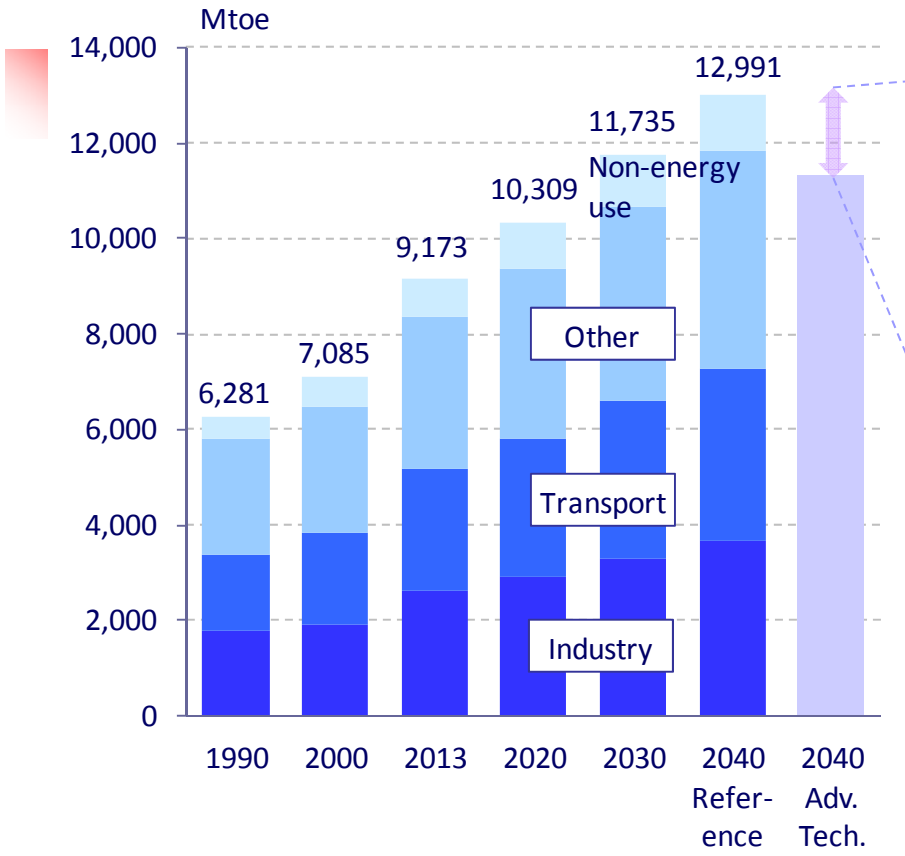



- In 2040, coal still accounts for the largest share of power generation. Natural gas-fired power plants globally increase on the introduction of natural gas combined cycle plants. Renewable energy sources including wind and solar energy also expand their share of power generation.
- In the Advanced Technologies Scenario, coal's share of power generation declines to 24%, while nuclear, hydro and other renewable energy sources expand their respective shares.

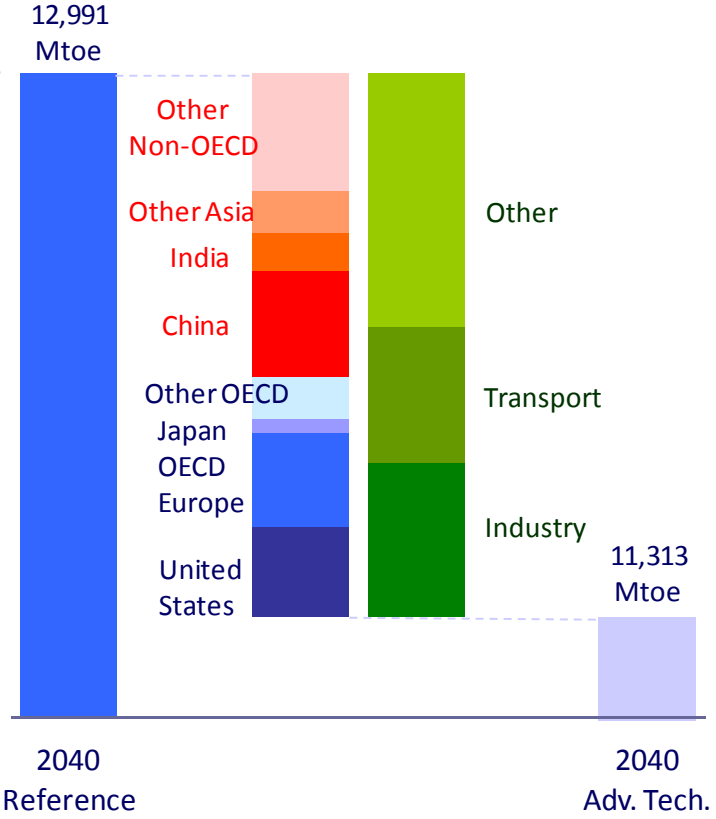
Source: IEEJ, "Asia/World Energy Outlook 2015"

# Energy saving in 2040 by region and by sector

## Global final energy demand




## Energy saving by region and by sector

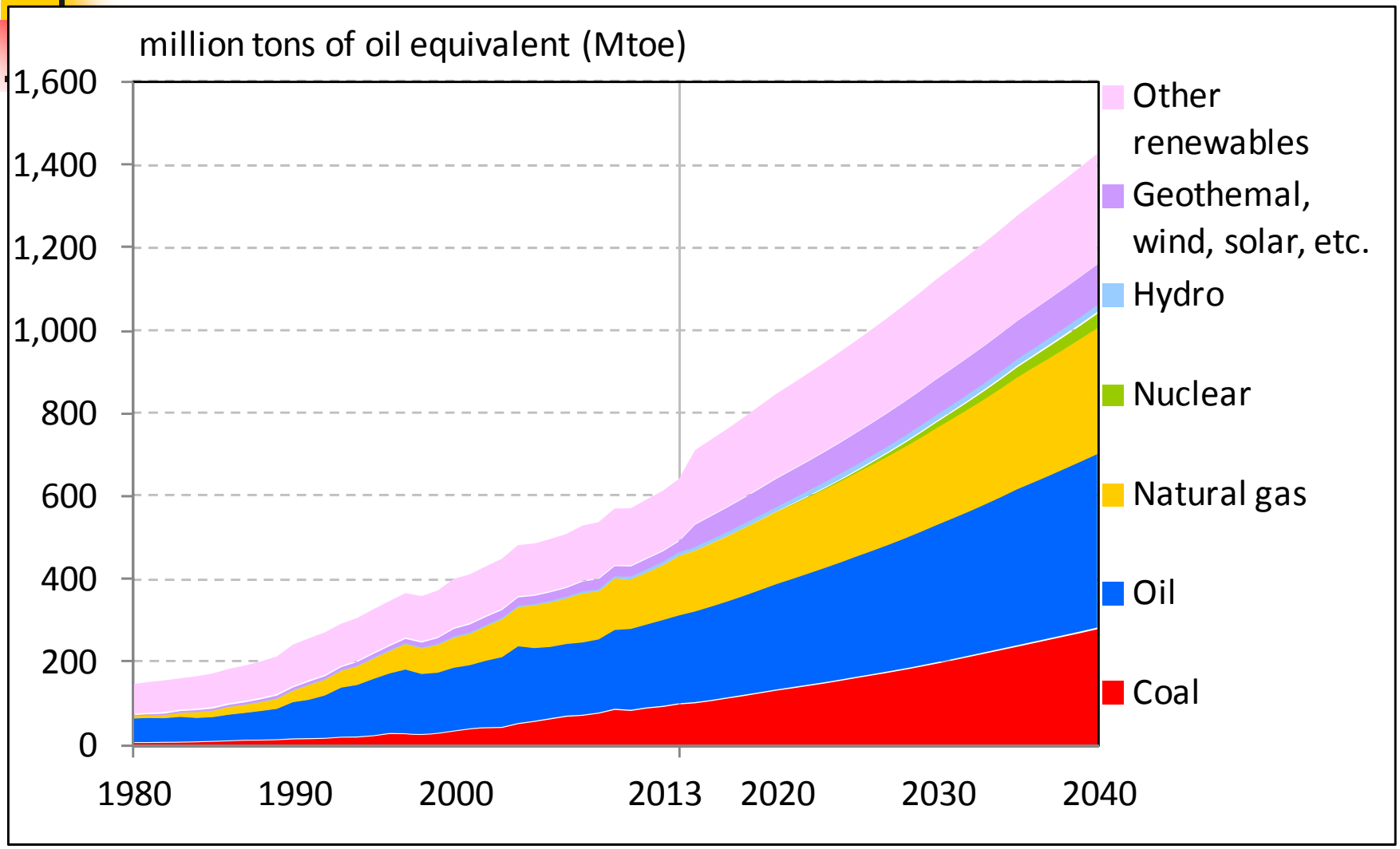



- Global final energy demand expands 1.4-fold from 9,173 Mtoe in 2013 to 12,991 Mtoe in 2040 in the Reference Scenario.
- In the Advanced Technologies Scenario, final energy demand in 2040 is reduced by 13% to 11,313 Mtoe. 60% of the energy saving is attributable to non-OECD countries. By sector, "other" sector including residential and commercial sectors accounts for nearly half (47%) of total energy saving.

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

# ASEAN Energy Demand Outlook (Reference case)

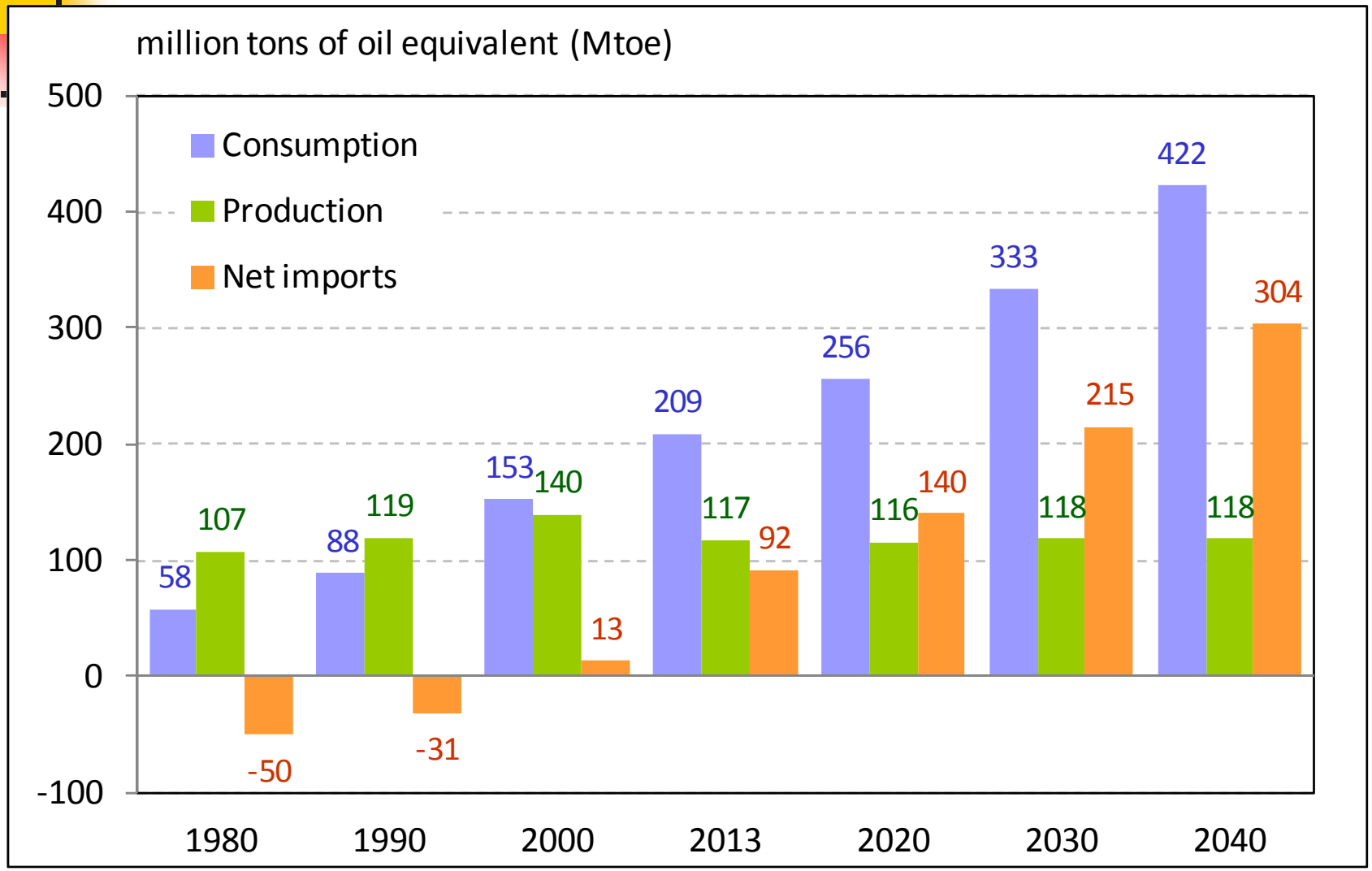
## Demand continued to expand, with fossil fuels as dominant source




Source: IEEJ, “Asia/World Energy Outlook 2015”

# ASEAN Oil Supply-Demand Outlook (Reference case)

## ASEAN will be increasingly import dependent

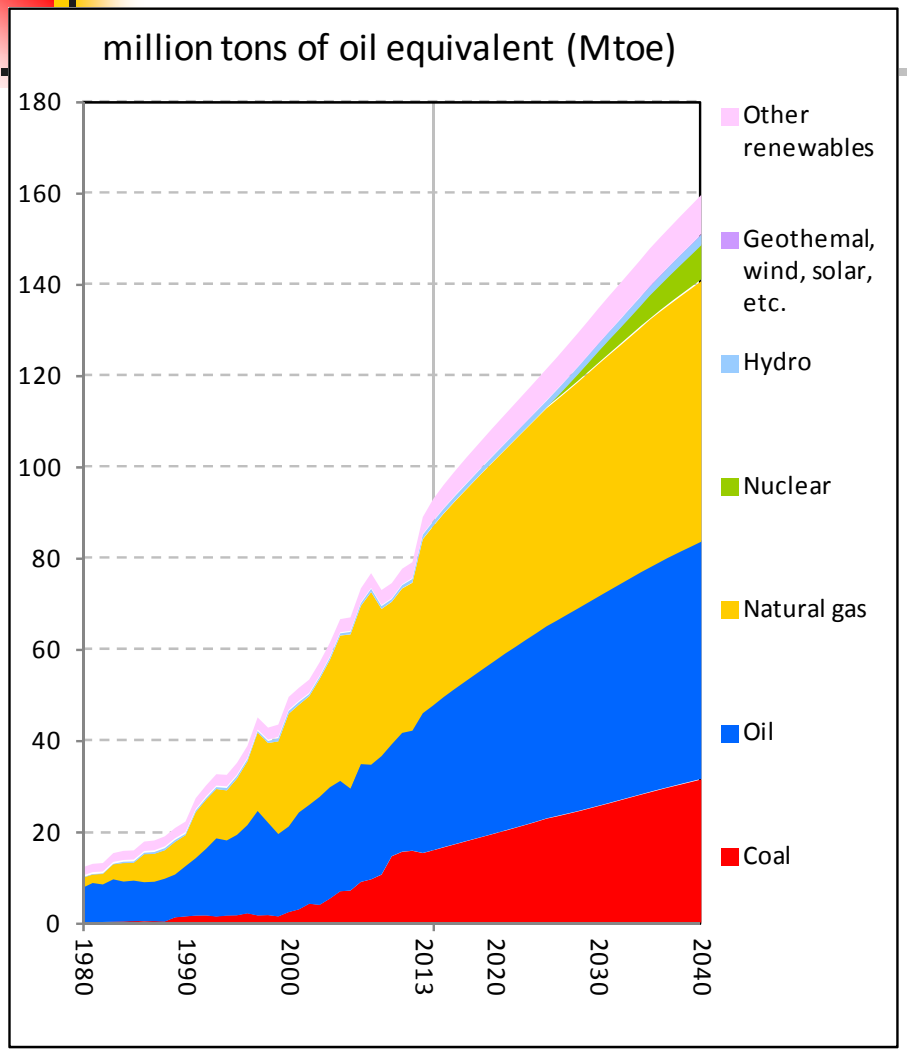



Source: IEEJ, “Asia/World Energy Outlook 2015”

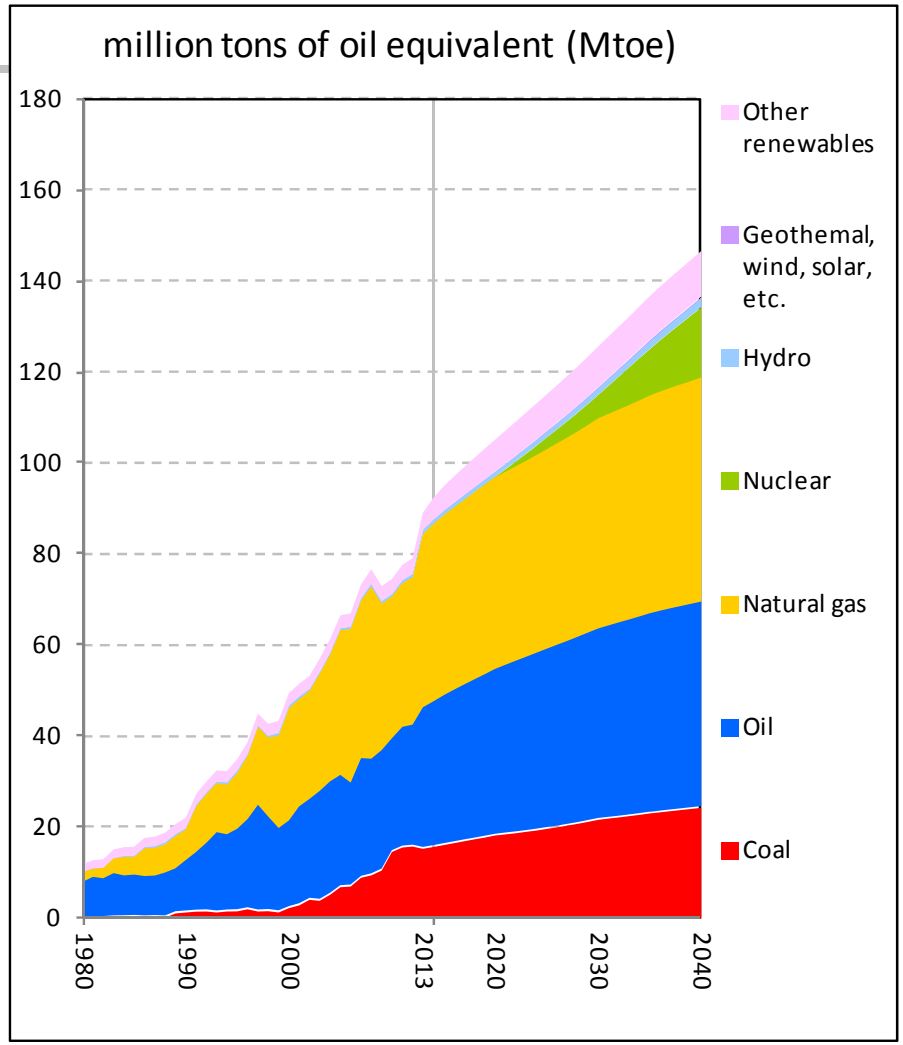
# Malaysia Energy Demand Outlook

## Demand expected to rise, but technology makes difference

**Reference case**

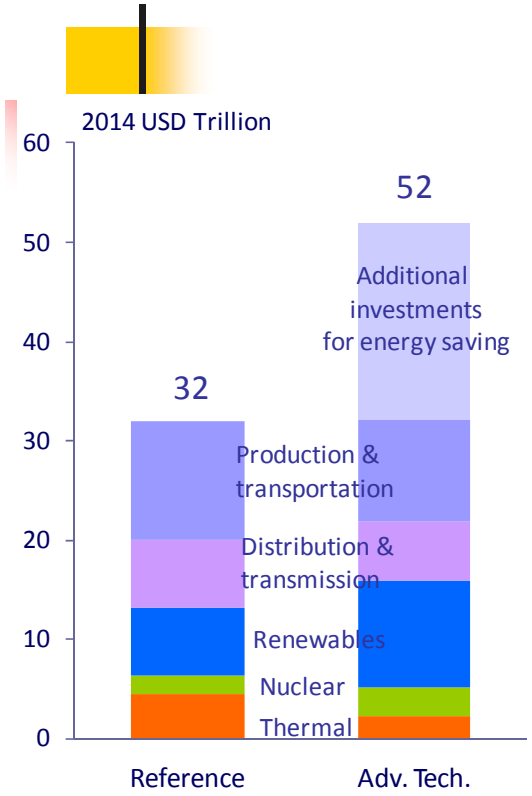


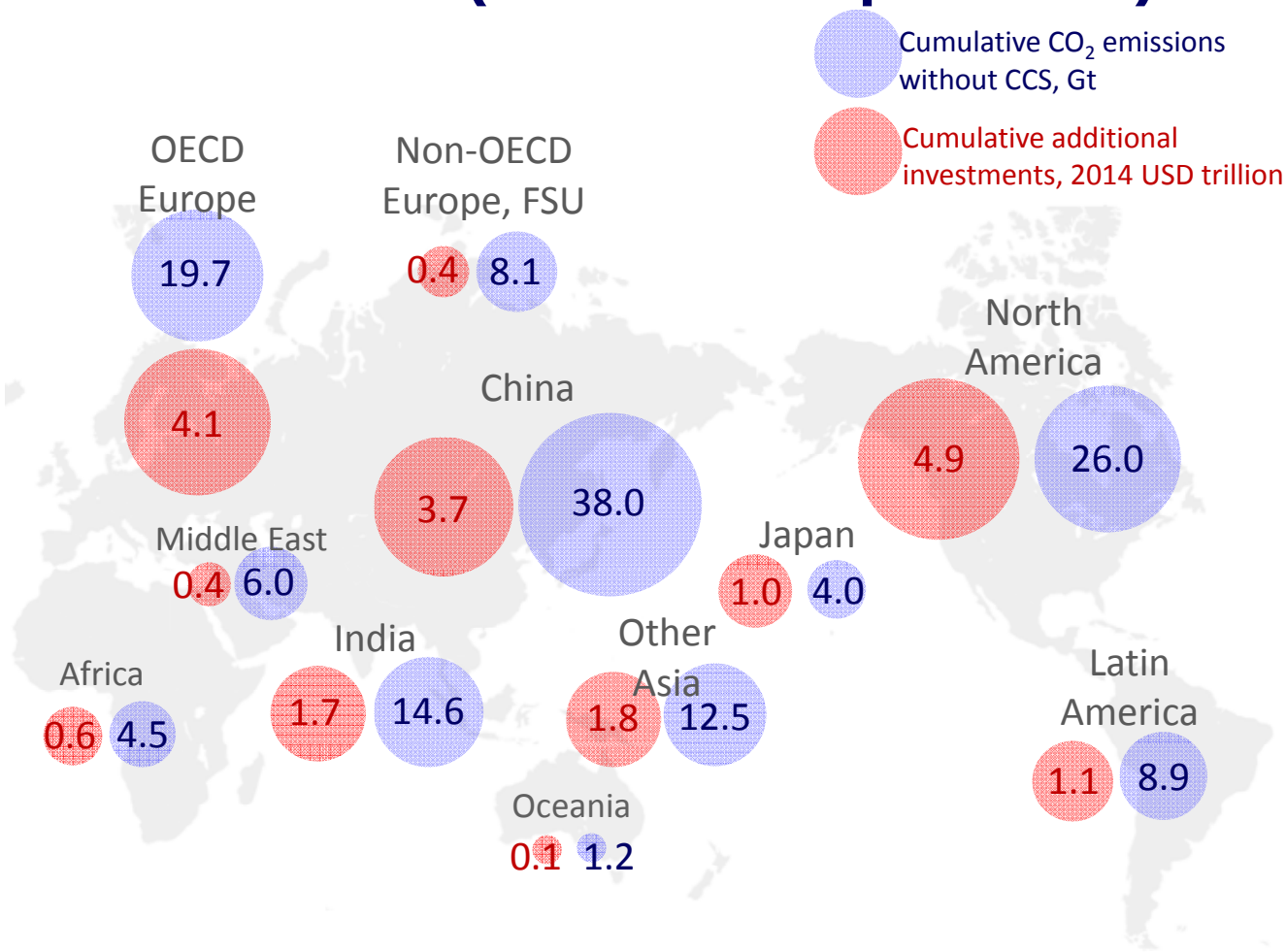

**Advanced Tech Case**




Source: IEEJ, “Asia/World Energy Outlook 2015”

# Required Capital Investment (cumulative up to 2040)



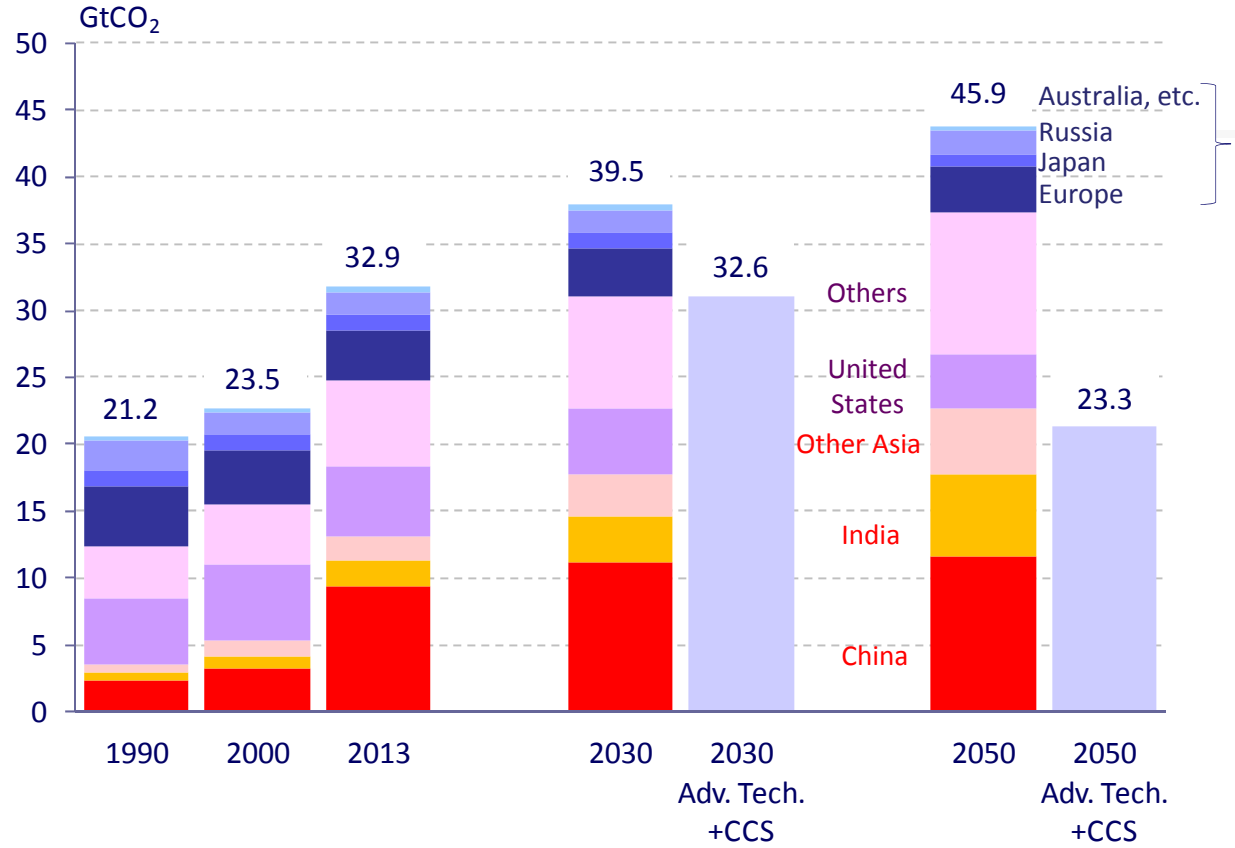




- On the supply side, while energy supply decreases in the Advanced Technologies Scenario, investments on renewable energy (etc.) expand and the cumulative investments up to 2040 are the same level as the Reference Scenario.
- On the demand side, additional investments of over 20 trillion USD are required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

Source: IEEJ, “Asia/World Energy Outlook 2015”

# $CO_2$ Emissions by region

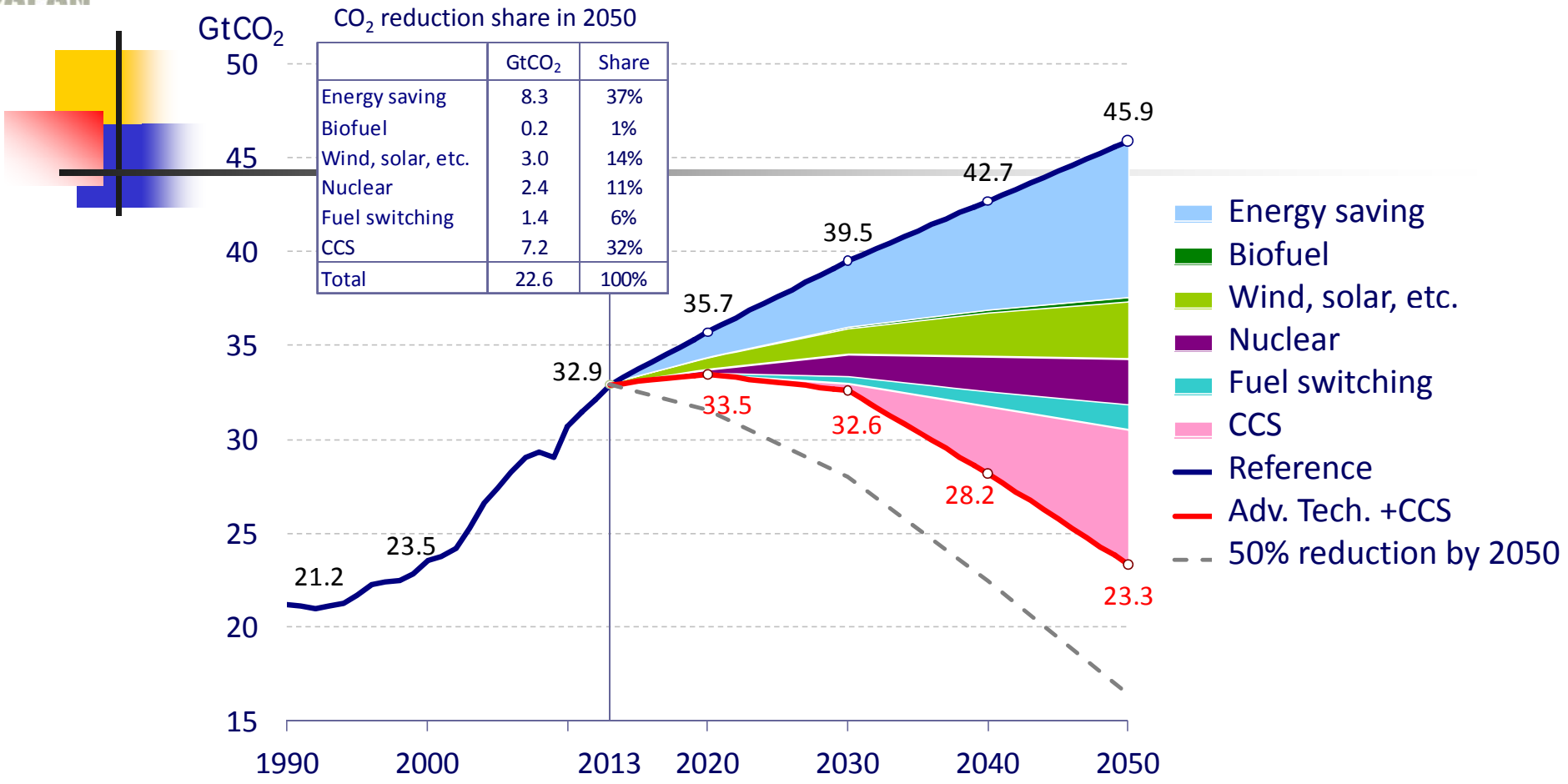
Note: Total figures include international bunkers.




- Global energy-related $CO_2$ 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.

Source: IEEJ, “Asia/World Energy Outlook 2015”

# $CO_2$ 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 global $CO_2$ 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”

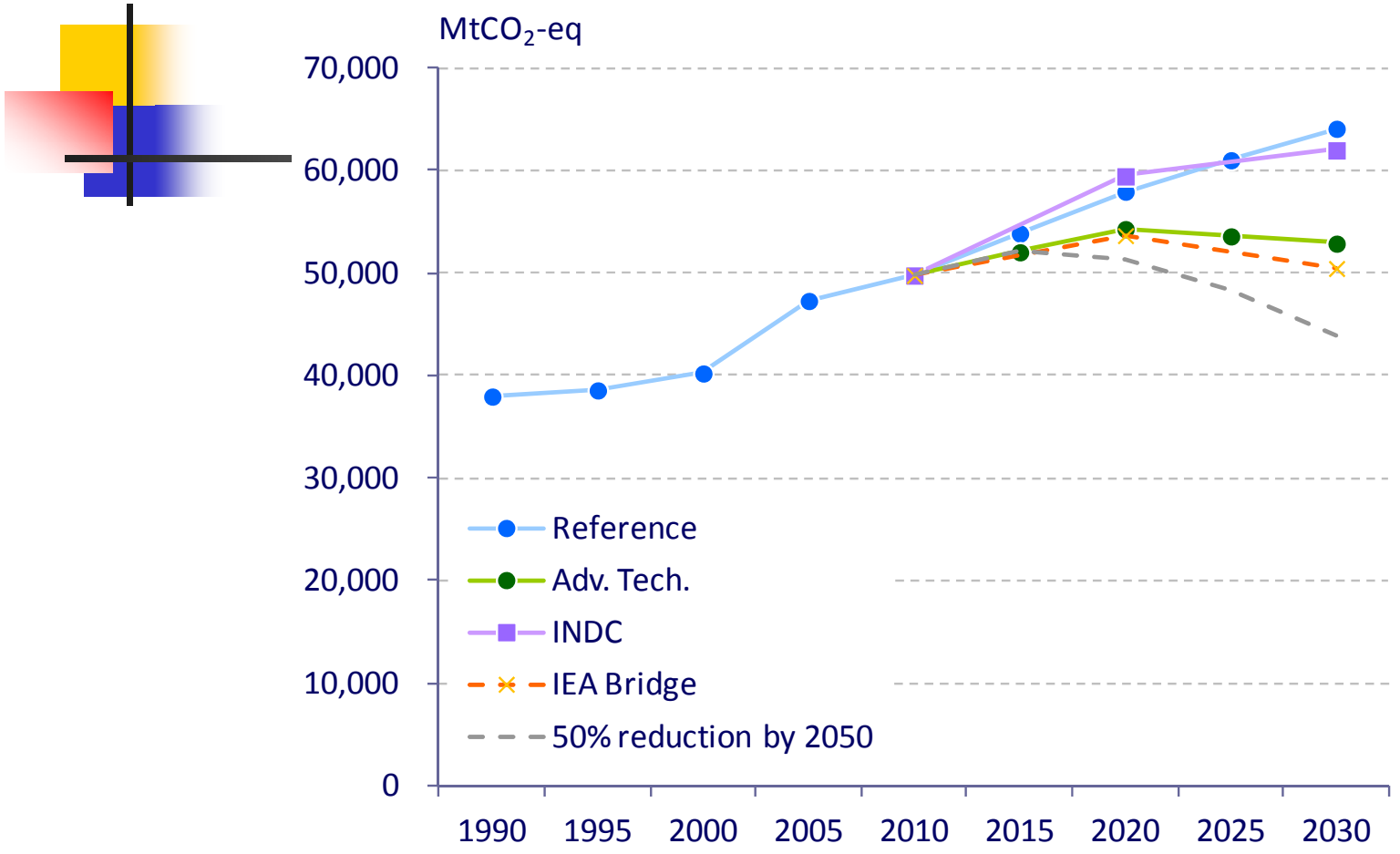
# Intended Nationally Determined Contributions by Country

| 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 the United Nations Climate Change Conference (COP21) in Nov. 2015, the participating countries have submitted the Intended Nationally Determined Contributions (INDCs) which present the post-2020 climate actions each country intends to take.
- By Oct 1st, 117 countries and regions (totaling 144 countries) have 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”

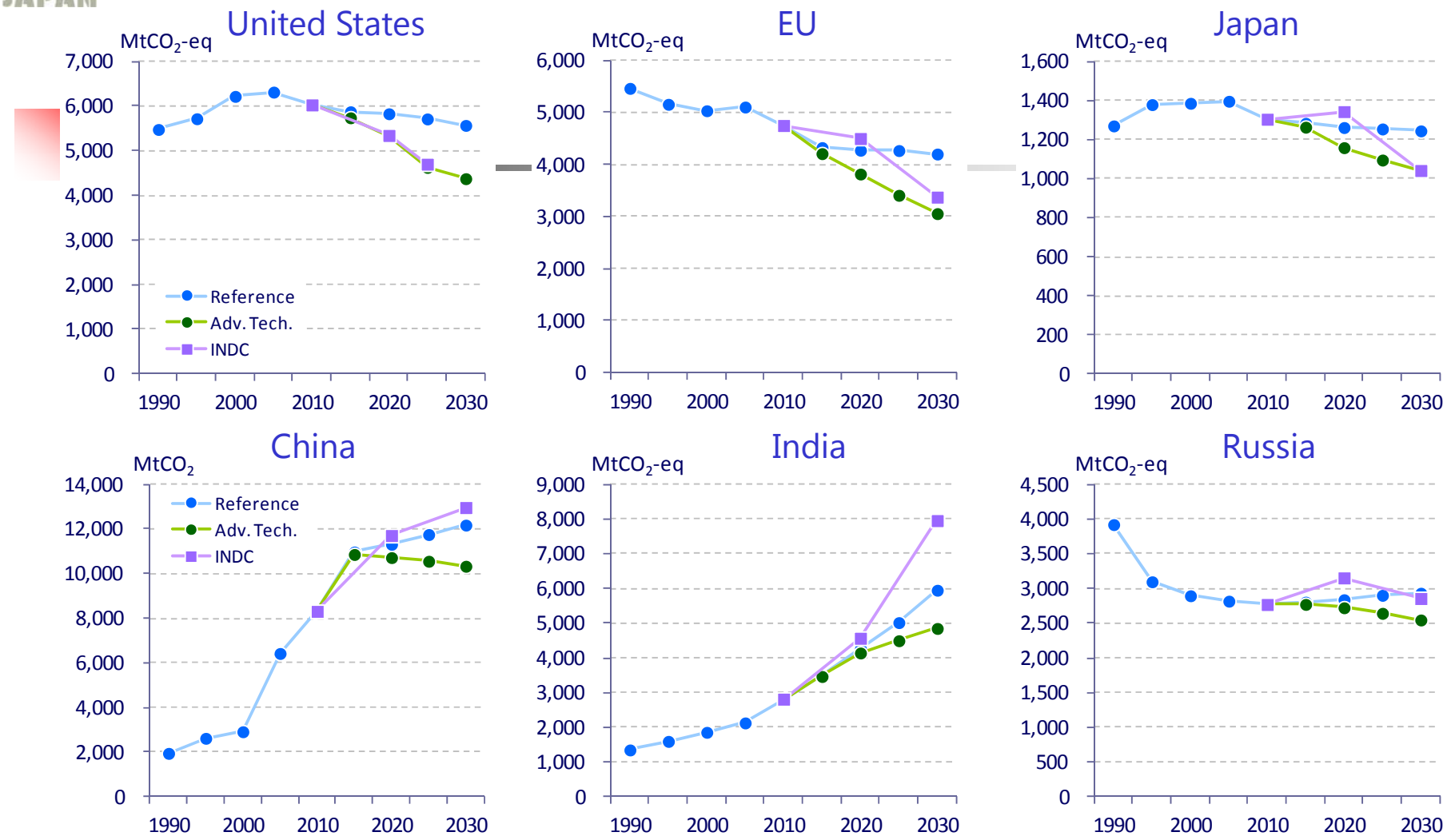
# Comparison of INDCs with the IEEJ Outlook




- 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."

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

# Comparison of INDCs with IEEJ Outlook by country

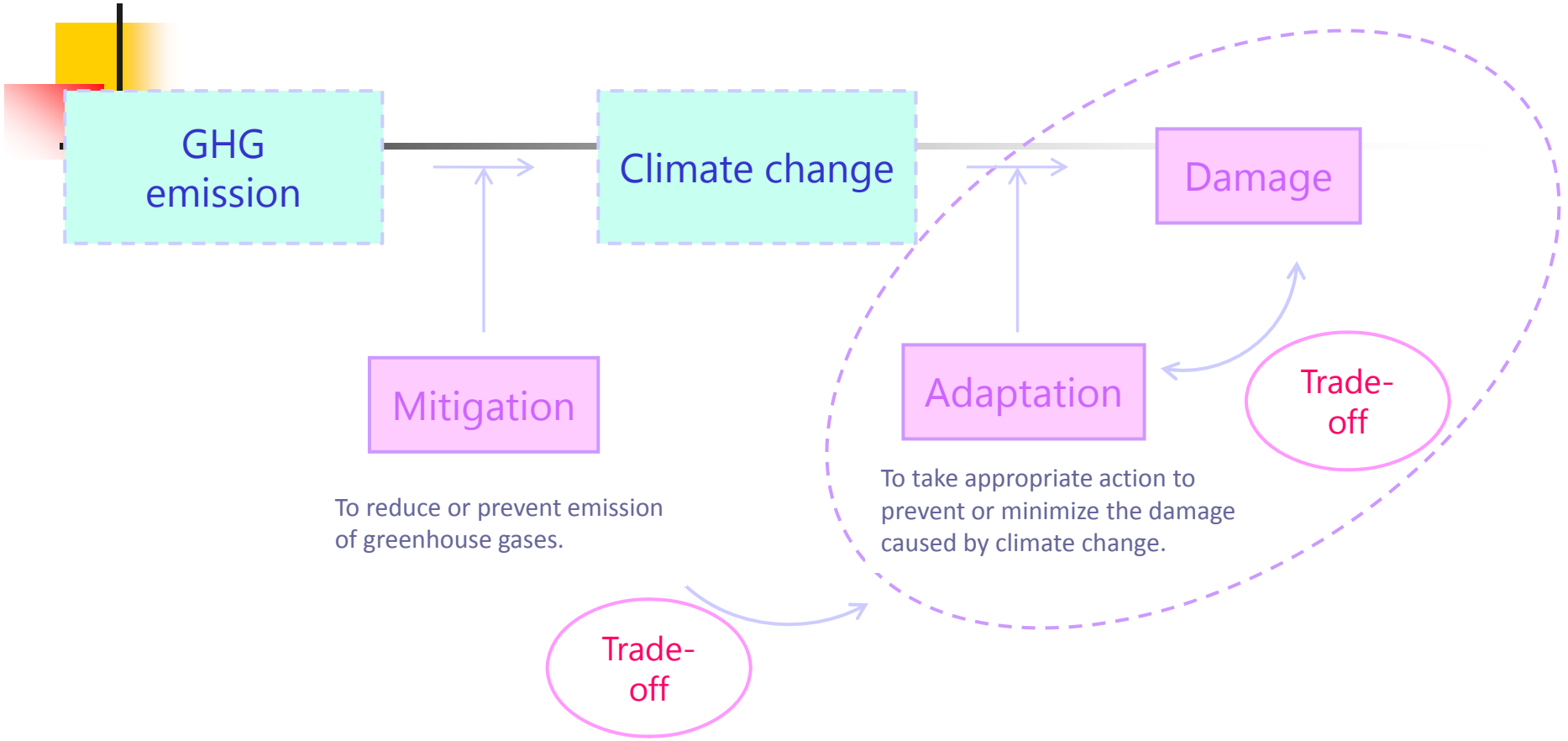



- The INDC targets of the United States and Japan are as ambitious as the Advanced Technologies Scenario. The target of EU is also positioned near the ATS.
- The targets of China and India exceed the Reference Scenario in terms of $CO_2$/GHG emissions.

Note: Japan's 2020 target does not include reduction by nuclear power. China's target is for $CO_2$, while others are for GHG.

Source: IEEJ, "Asia/World Energy Outlook 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 three costs at the same time.
- It would be realistic to expect a balance among the three, while minimizing the total cost.

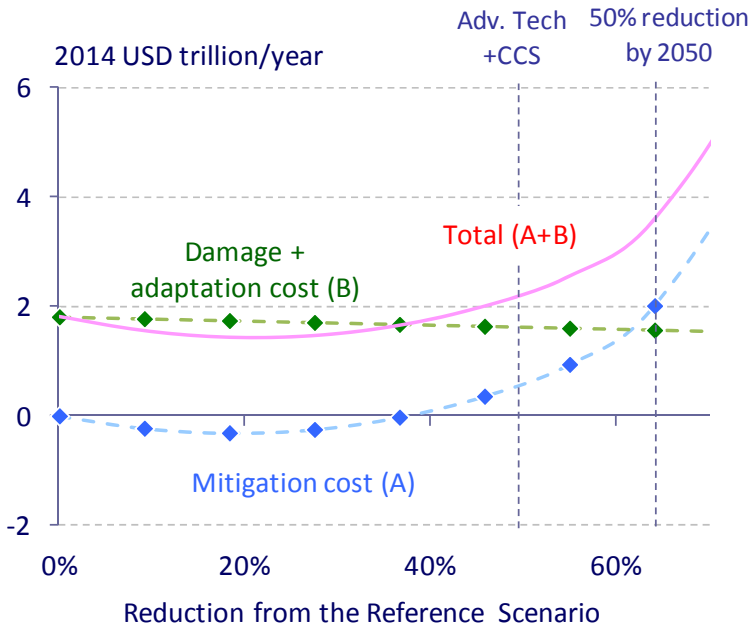
Source: IEEJ, “Asia/World Energy Outlook 2015”

# Mitigation vs. adaptation and damage

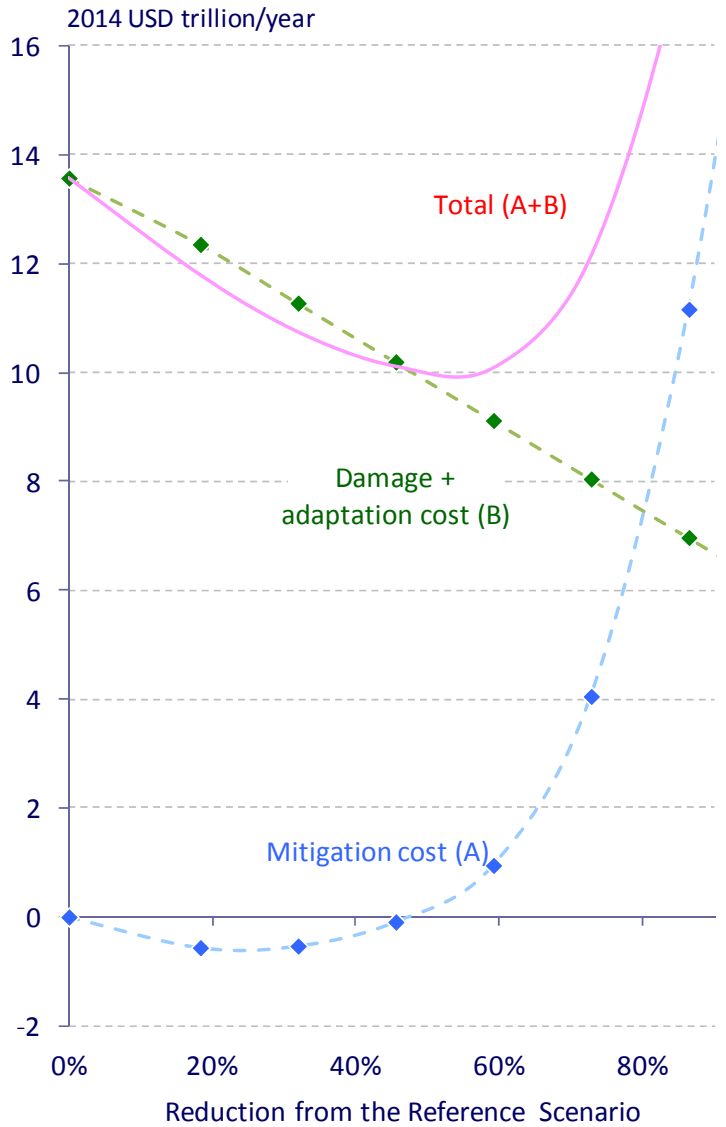
Mitigation cost: estimated by IEEJ
Damage + adaptation cost: calculated using the formula in the DICE 2013Rmodel
Climate sensitivity assumed at 3° C.

- 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

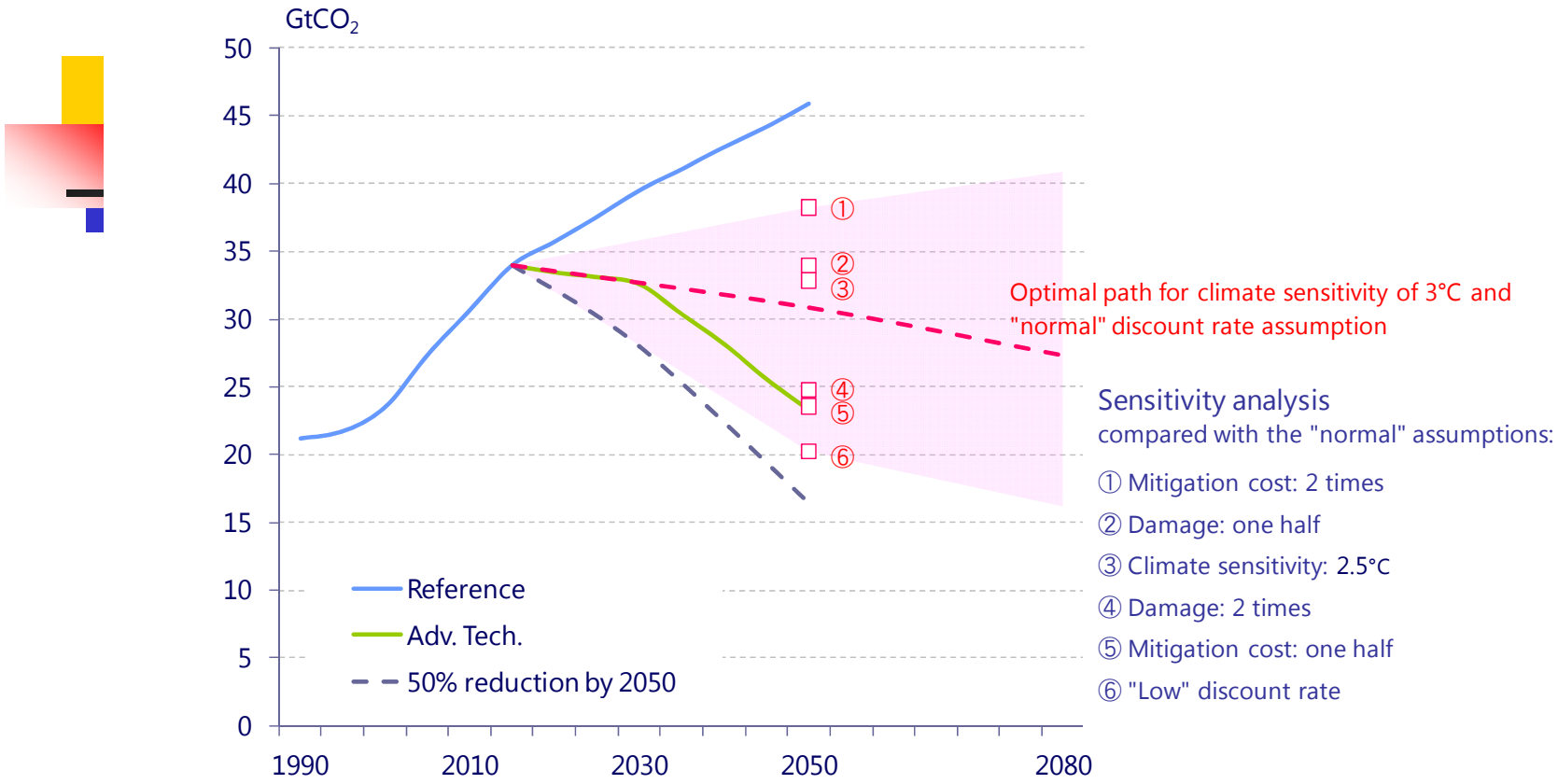



2100




Source: IEEJ, “Asia/World Energy Outlook 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 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 $CO_2$ reduction ratios.

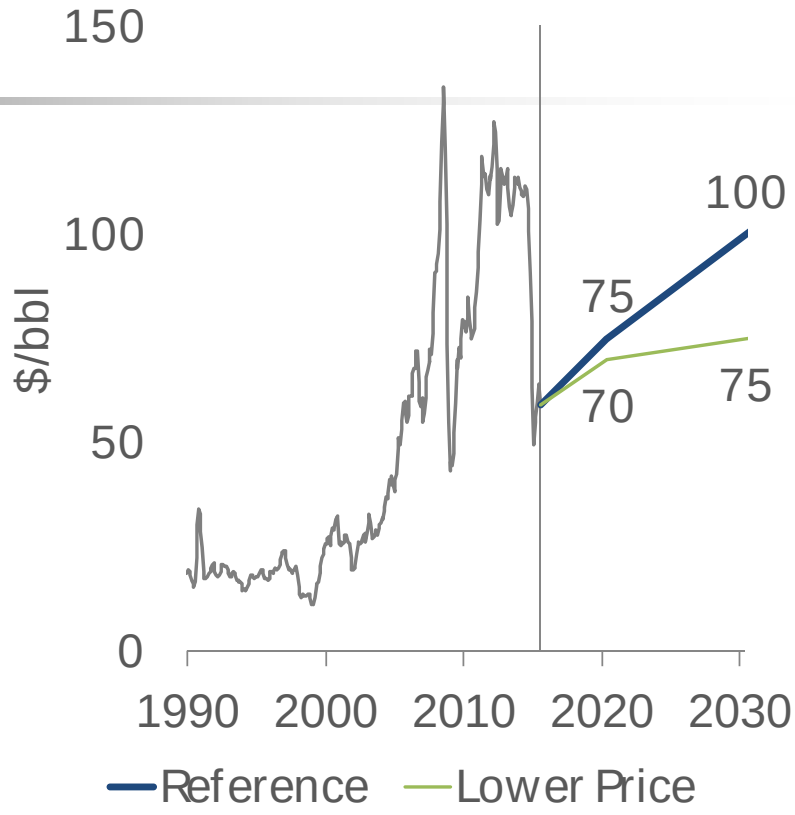
Source: IEEJ, “Asia/World Energy Outlook 2015”

# 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** | **Conventional resources**<br>Development in each country follows its historical trend.<br>**Unconventional resources**<br>Production growth in the United States declines in and after 2020s.<br>Slow development is seen in other countries. | **Conventional resources**<br>Competition among low-cost producers such as OPEC, Russia, etc. continues.<br>OPEC effectively loses its power as a cartel organisation.<br>**Unconventional resources**<br>Reach the highest levels both inside and outside the United States. |

## ❖ Assumption of oil price



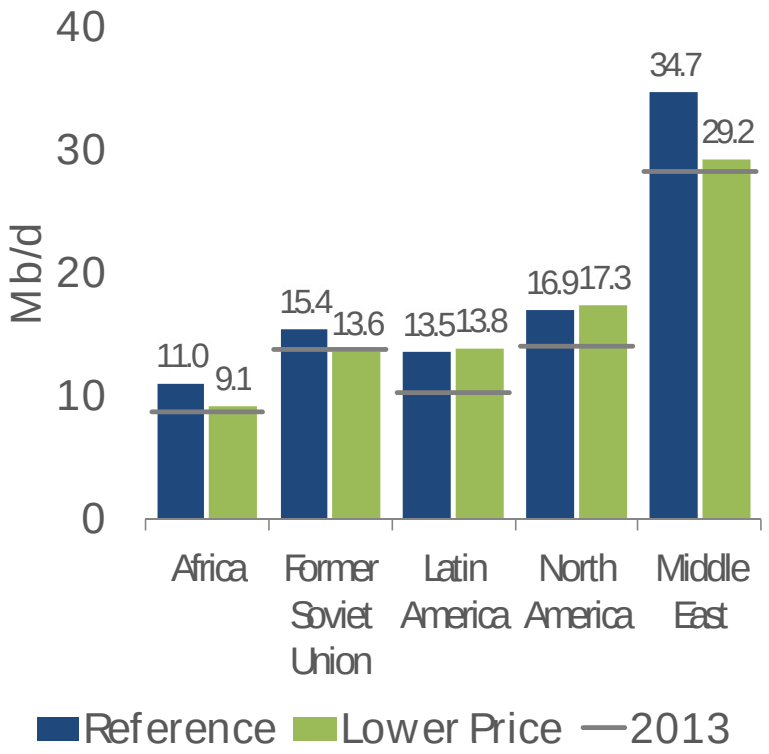

Note: Future prices are in $2014.

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.

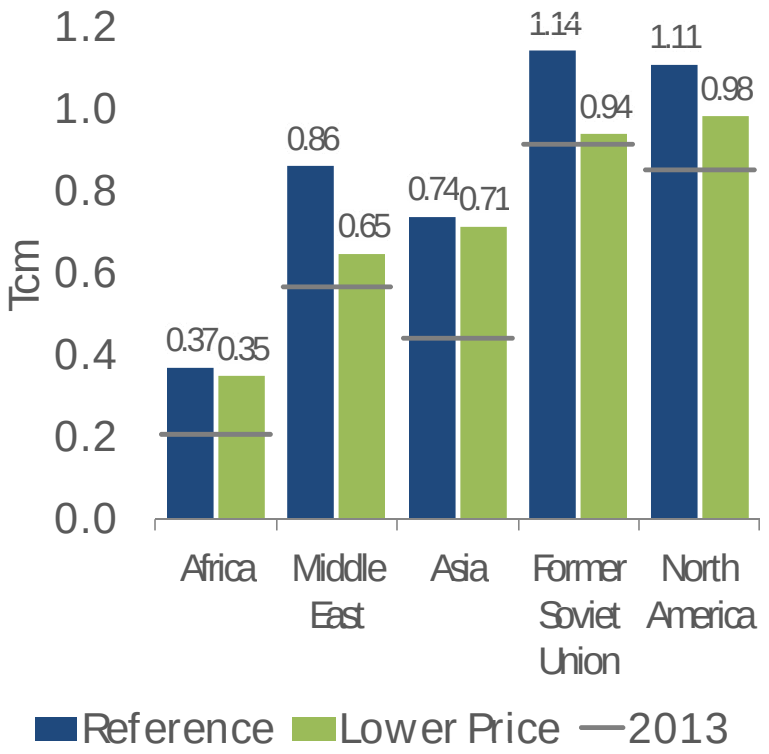
Source: IEEJ, "Asia/World Energy Outlook 2015"

# Depressed production in traditional exporting regions

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




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



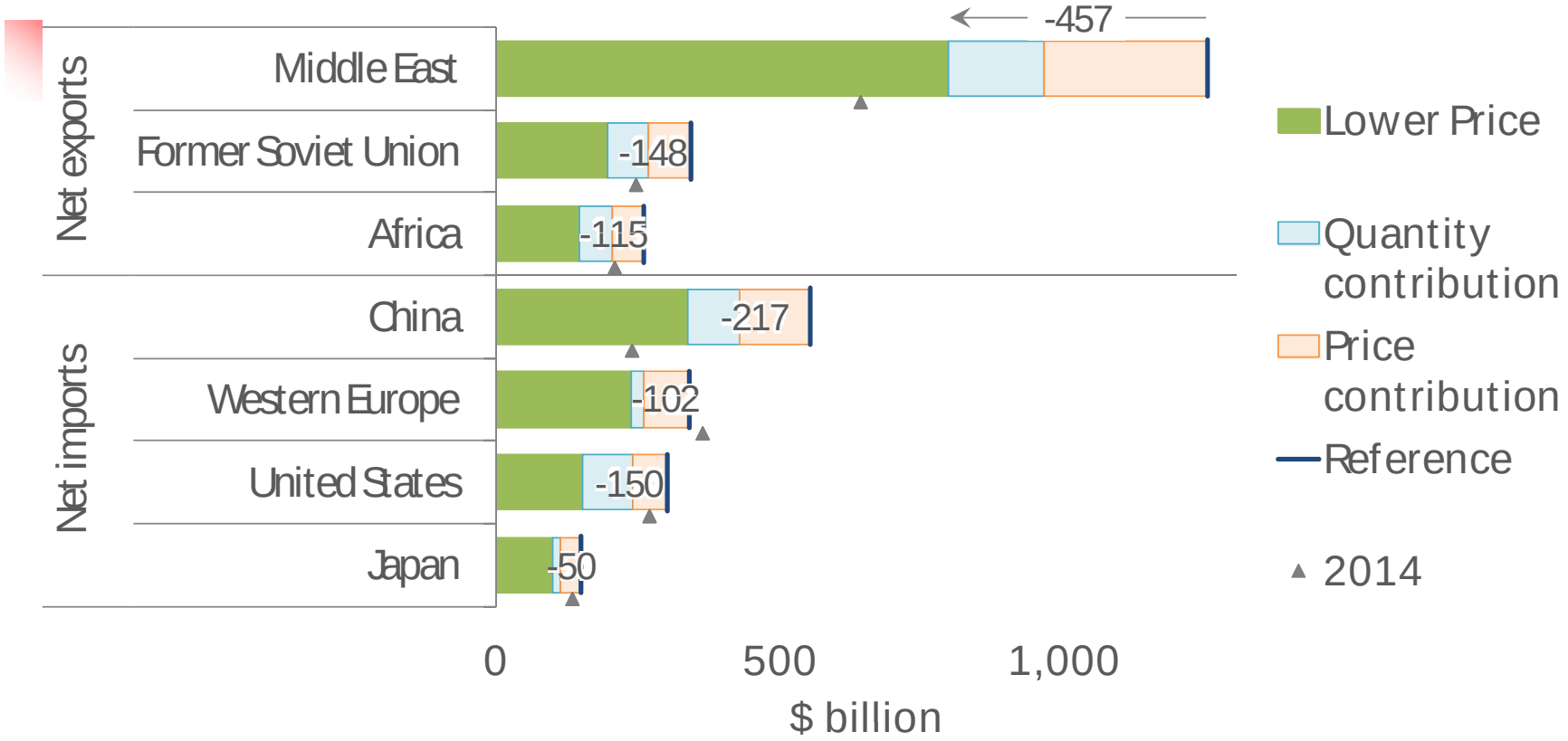

Global oil supply in 2030 is 96.5 Mb/d, increased by just 7.7 Mb/d from today, due to the assumed strong energy conservation and fuel switching to other energies.

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"

# Low oil price impact on exporter and importer

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



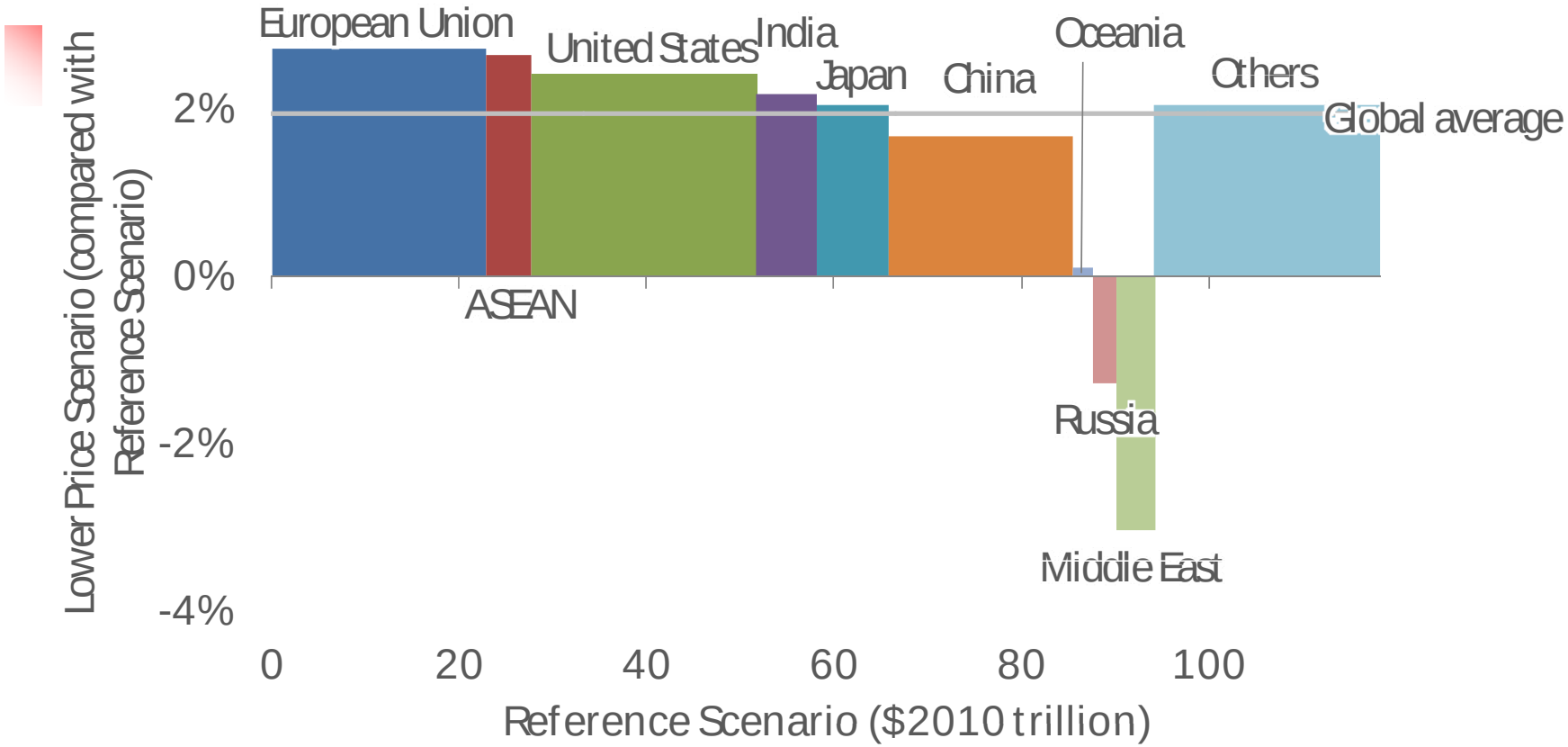

Oil saving, lower oil price and wider use of unconventional resources make international trade of crude oil* 36% less, to $2.8 trillion from $4.4 trillion, in the Reference Scenario. * Among the modelled 15 regions. Nominal value.

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.

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

# 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.

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

# Instability in the Middle East

Terrorist Attacks In Paris

Uncertainty over Middle East Peace issues

Iraqi situations after the war

Tensions on Iran Nuclear development

Rising energy demand and its impacts

Immigrants to Europe

Post-sanction Iran?

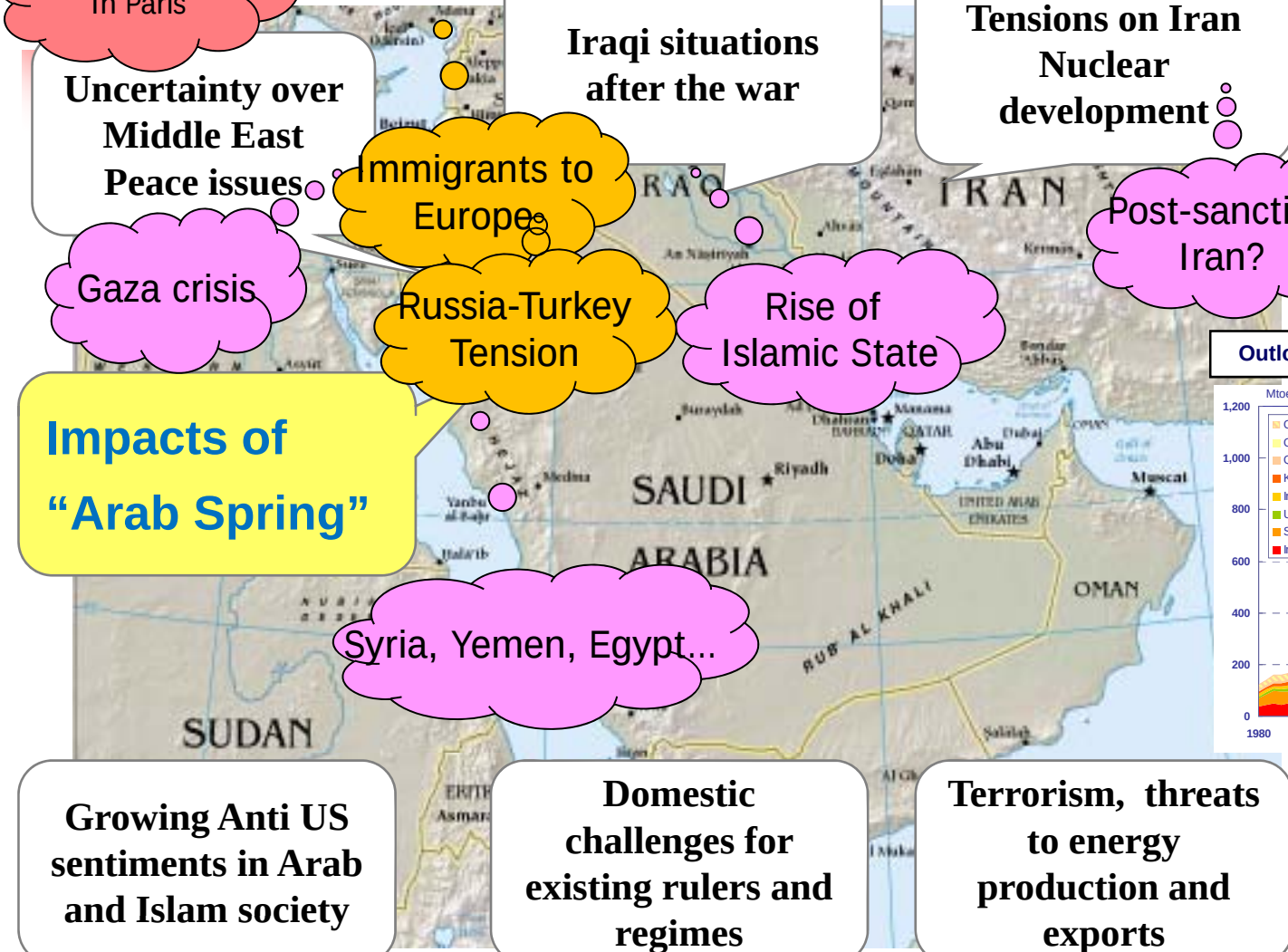
Gaza crisis

Russia-Turkey Tension

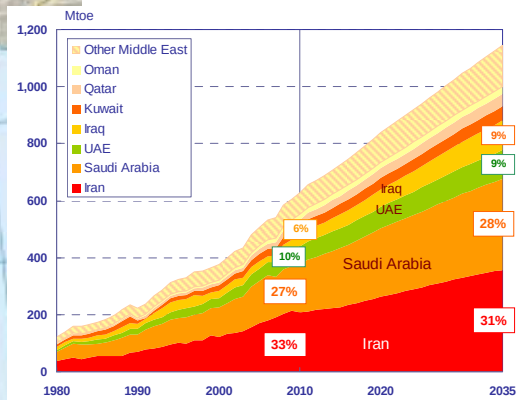
Rise of Islamic State

**Impacts of "Arab Spring"**

Syria, Yemen, Egypt...




**Outlook for energy demand in Middle East**




**Growing Anti US sentiments in Arab and Islam society**

**Domestic challenges for existing rulers and regimes**

**Terrorism, threats to energy production and exports**

**Source: Prepared by IEEJ**

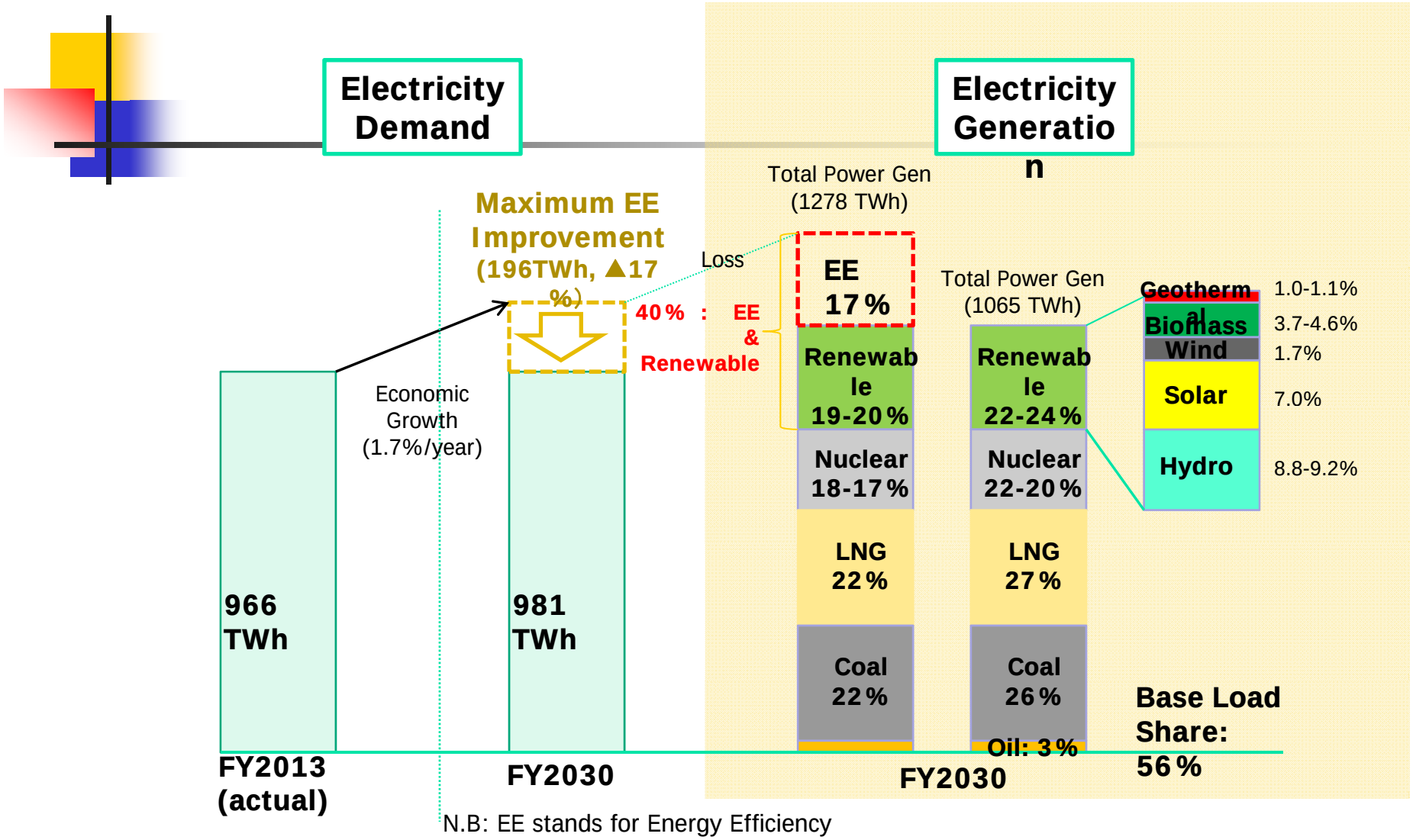
# Challenges for Japan's Energy Policy

- **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”

- 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

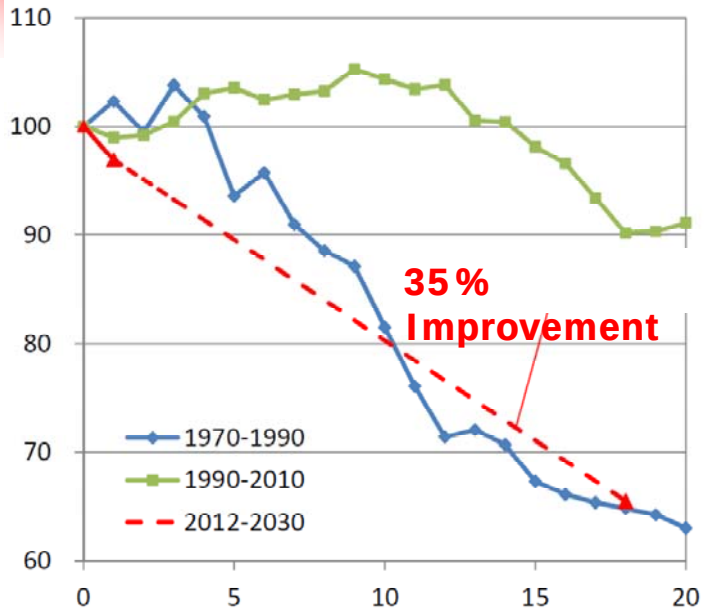



Source: from documents discussed at the
"Long-term Energy Outlook Sub Committee", 10th Session (1st June 2015)

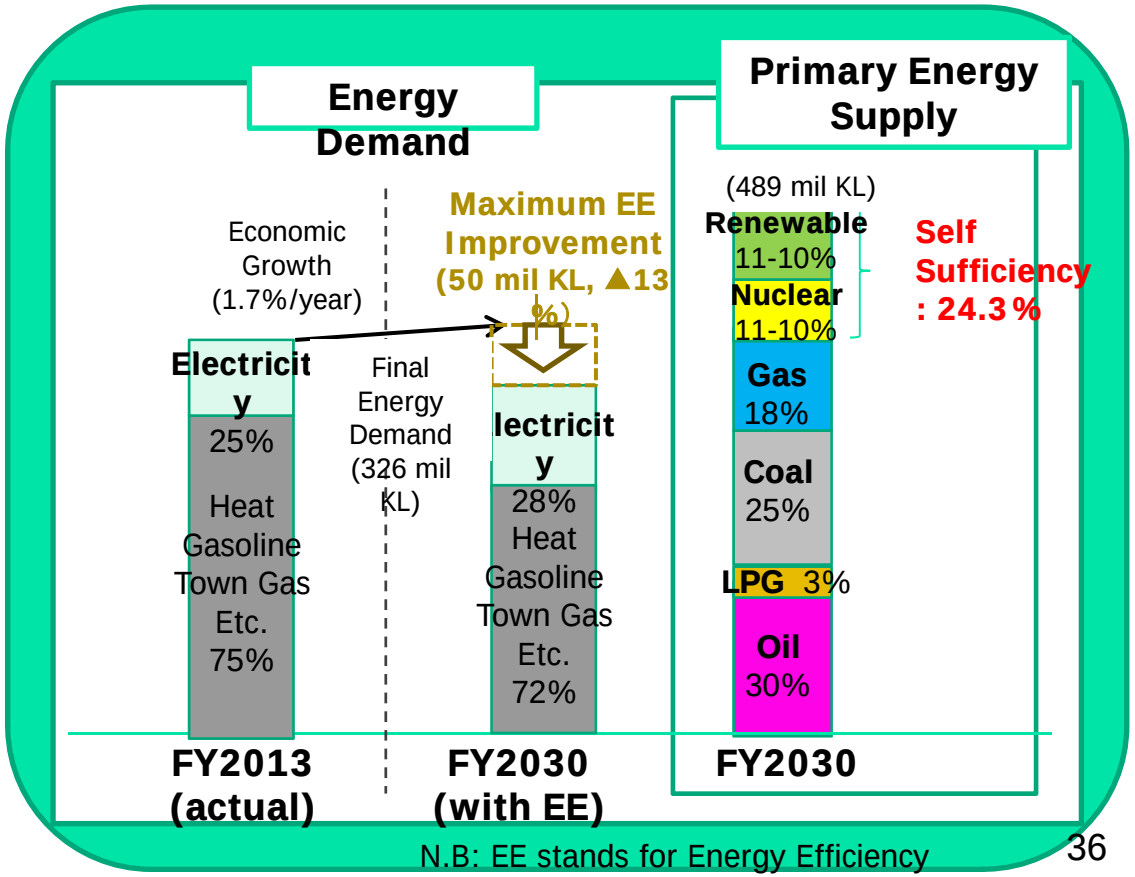
# Energy Efficiency to be Improved Drastically

## 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 |

Source: Prepared by Data from METI

# 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) |

Source: Prepared by the Author based on METI data

# Four Issues to be Tackled

- Address new developments in Japan and the world
  - **Systems Reform**
  - **Oil price volatility, Middle East situation uncertainty, etc.**
- Key to a success: more detailed measures to meet targets
  - **Needs for more concrete measures and roadmaps for policy implementation**
  - **Sincere efforts to obtain better understanding from citizens**
- Needs for Longer-term strategies beyond 2030
  - **Development of advanced technologies (e.g. Hydrogen, CCS+U, etc.)**
  - **methane hydrate, etc.**
- Revision of “Long-term Energy Outlook “on regular basis
  - **Revisit the Outlook when “Basic Energy Strategy” is revised (every 3 years).**

# Conclusion

- 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 )