Northeast Asia Petroleum Forum 2009

IEEJ ASIA/WORLD ENERGY OUTLOOK 2009

—The Role of Technology Towards the Resolution of Energy & Environmental Issues in Asia —

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Projection Outline

- **Objective：Quantitatively simulate world and Asian future energy pictures in a fully logical and consistent way, with elaborate investigation into current status of socio-economic and energy fundamentals.**

  In particular, detailed analysis of Asian region is implemented through the exchange of information with numerous agencies and government entities.

- **Projection Period：*2008～2035***

- **Methodology：** **Macro-Economic Model, Energy Demand and Supply Model, both developed on the basis of econometric model**

- **Scenarios:**

  –Reference

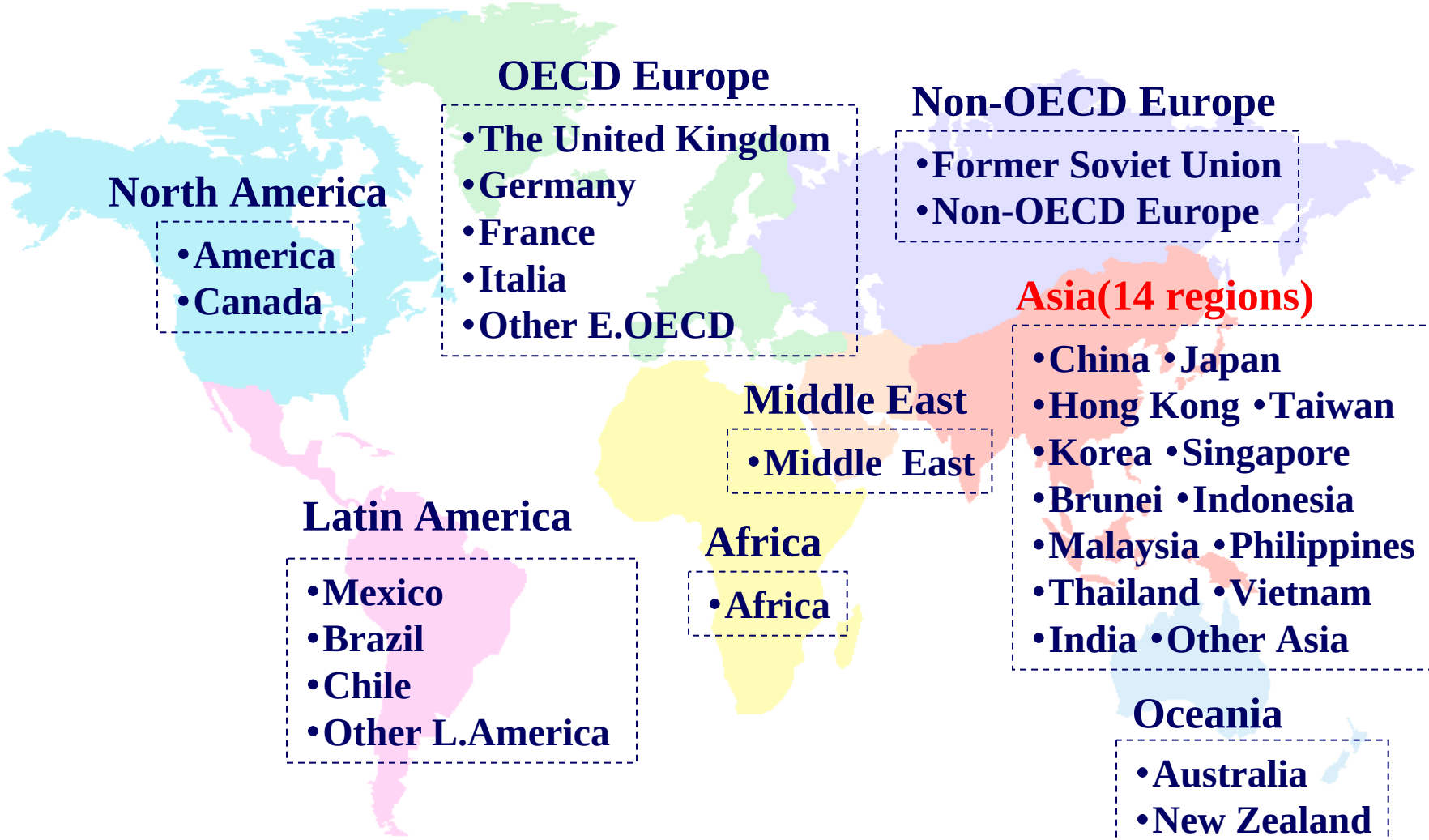
  Reference scenario provides a baseline picture which incorporates all policies and technologies related to energy security and climate mitigation enacted today. The scenario also assumes a probable deployment of those policies under consideration and technologies under development in some countries.

  –Advanced Technology Scenario

  This scenario develops future picture, in which every country introduce several advanced technologies in order to secure energy supply and mitigate environmental problem

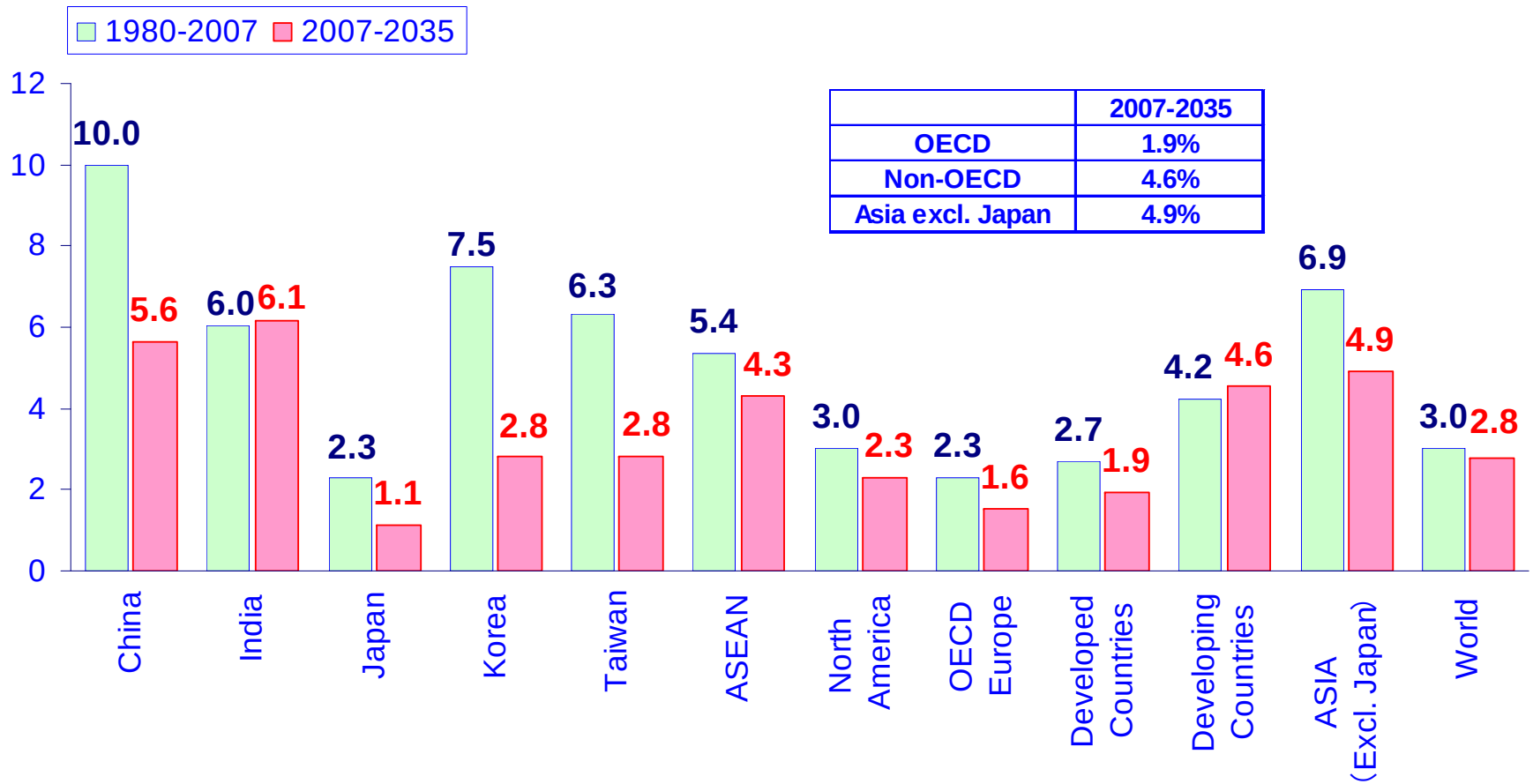
Geographical Coverage

- *The whole world is geographically divided into 31regions, Asia into 14 regions.*
- *Geopolitically detailed analysis into Asian countries.*



IEEJ: November 2009

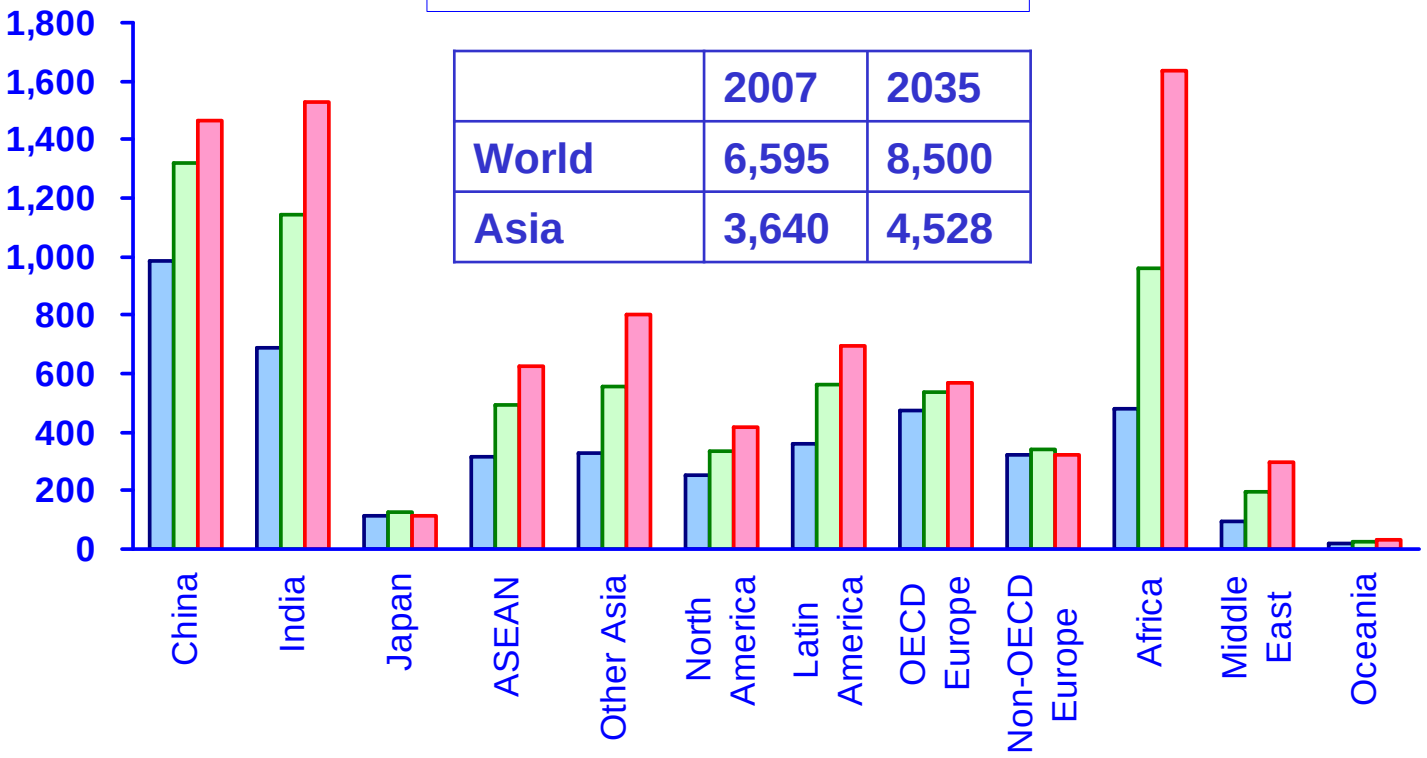
GDP（World）



	2007-2035
OECD	1.9%
Non-OECD	4.6%
Asia excl. Japan	4.9%

- *World economy is projected to grow at 2.8% per annum, driven mainly by developing countries.*
- *Because China's economic driver gradually changes from investment and export to domestic private consumption, GDP in China continues to achieve relatively high growth at 5.6%.*
- *India's GDP is assumed higher growth rate than today reflecting on improving economic efficiency by liberalization and direct investment from foreign countries.*

Population（World）



	2007	2035
World	6,595	8,500
Asia	3,640	4,528

China

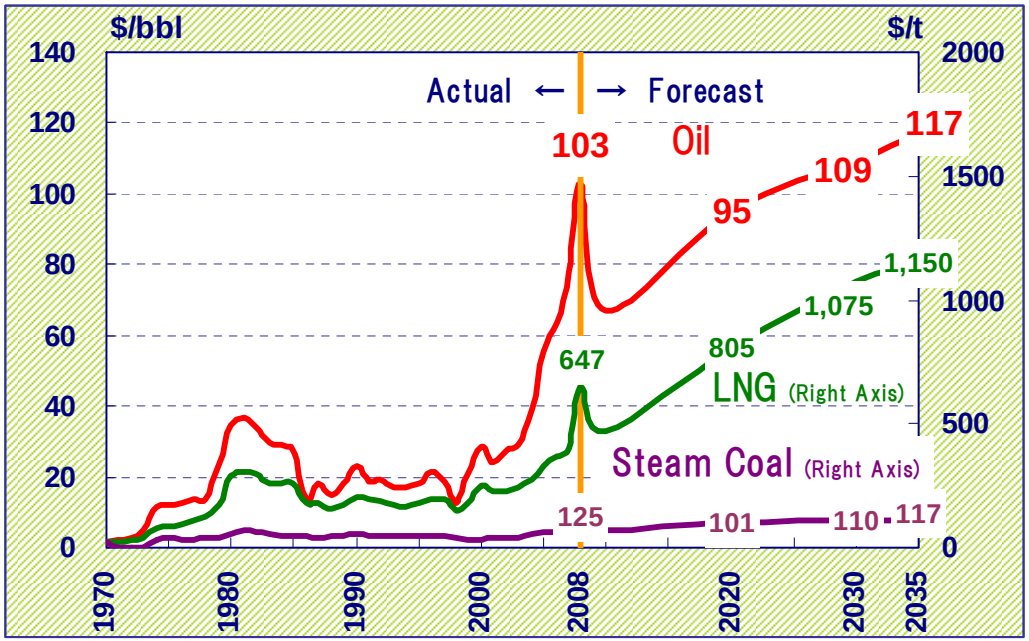
2007
1.32 bil.
↓
2035
1.46 bil.

India

2007
1.15 bil.
↓
2035
1.53 bil.

Of the incremental increase in population over the period 2008-2035, roughly 47% derives from Asian countries.
India's population is estimated to surpass China's population in 2035.

Primary Energy Price



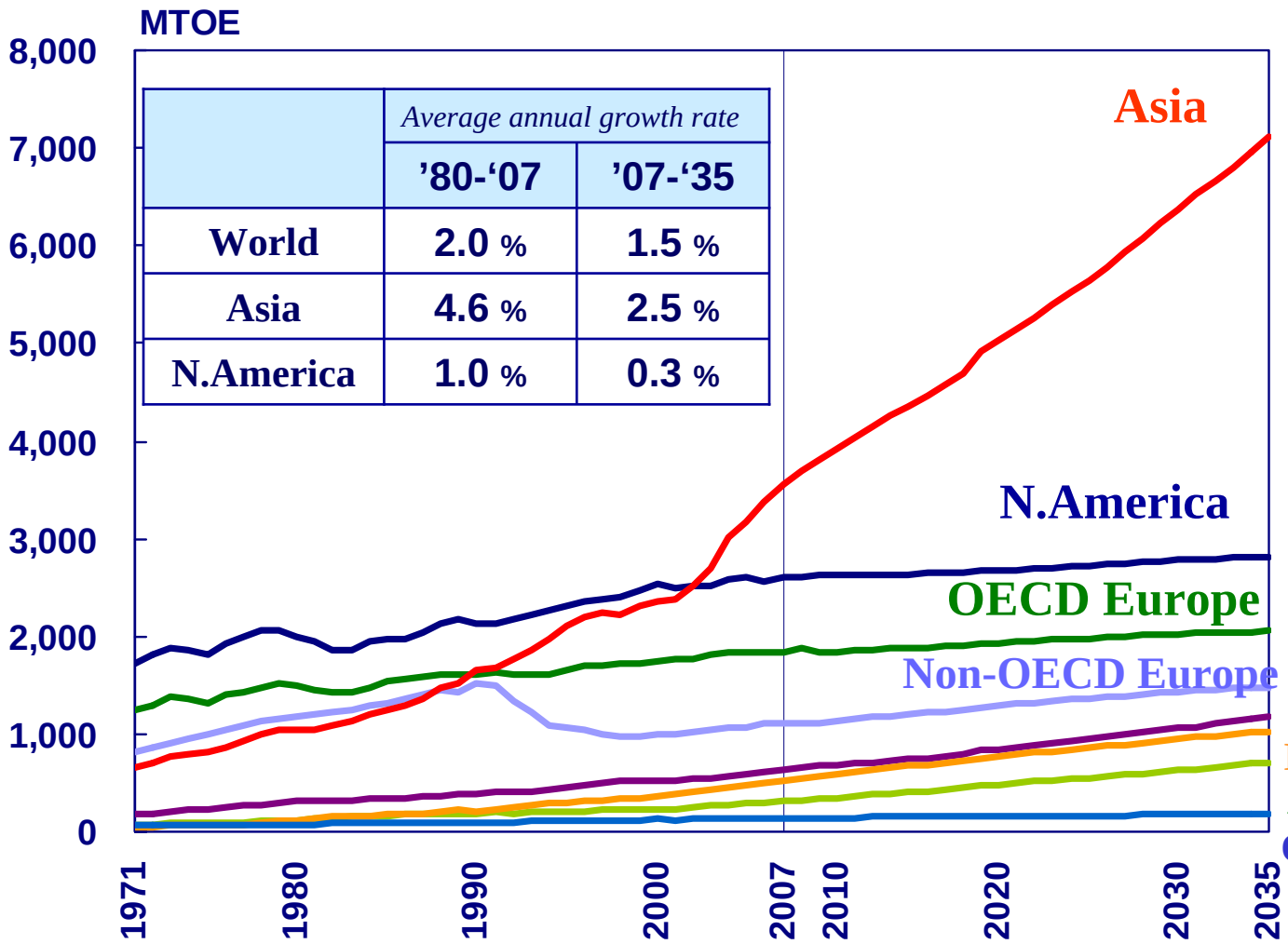
Cf. All the prices are calendar year data; future price is based on 2008 real price. ;In the graph, energy prices are explained by Japan's import energy price (CIF base).

- *Today's relatively high price of crude oil (import CIF price) will exhibit slowdown towards 2010. After 2010, international oil market will become tightened as a result of increasing oil demand mainly in Asia in addition with stagnation of investment in upstream sector.*
- *LNG price is projected to rise in accordance with crude oil price.*
- *Coal price remains almost unchanged.*

※Energy import prices (Japan) (FY2008)

petroleum :90.5 $/bbl, LNG :655.2$/t steam coal :133.6$/t

Primary Energy Demand by Region（World）



	Average annual growth rate	
	’80-‘07	’07-‘35
World	2.0 %	1.5 %
Asia	4.6 %	2.5 %
N.America	1.0 %	0.3 %

World

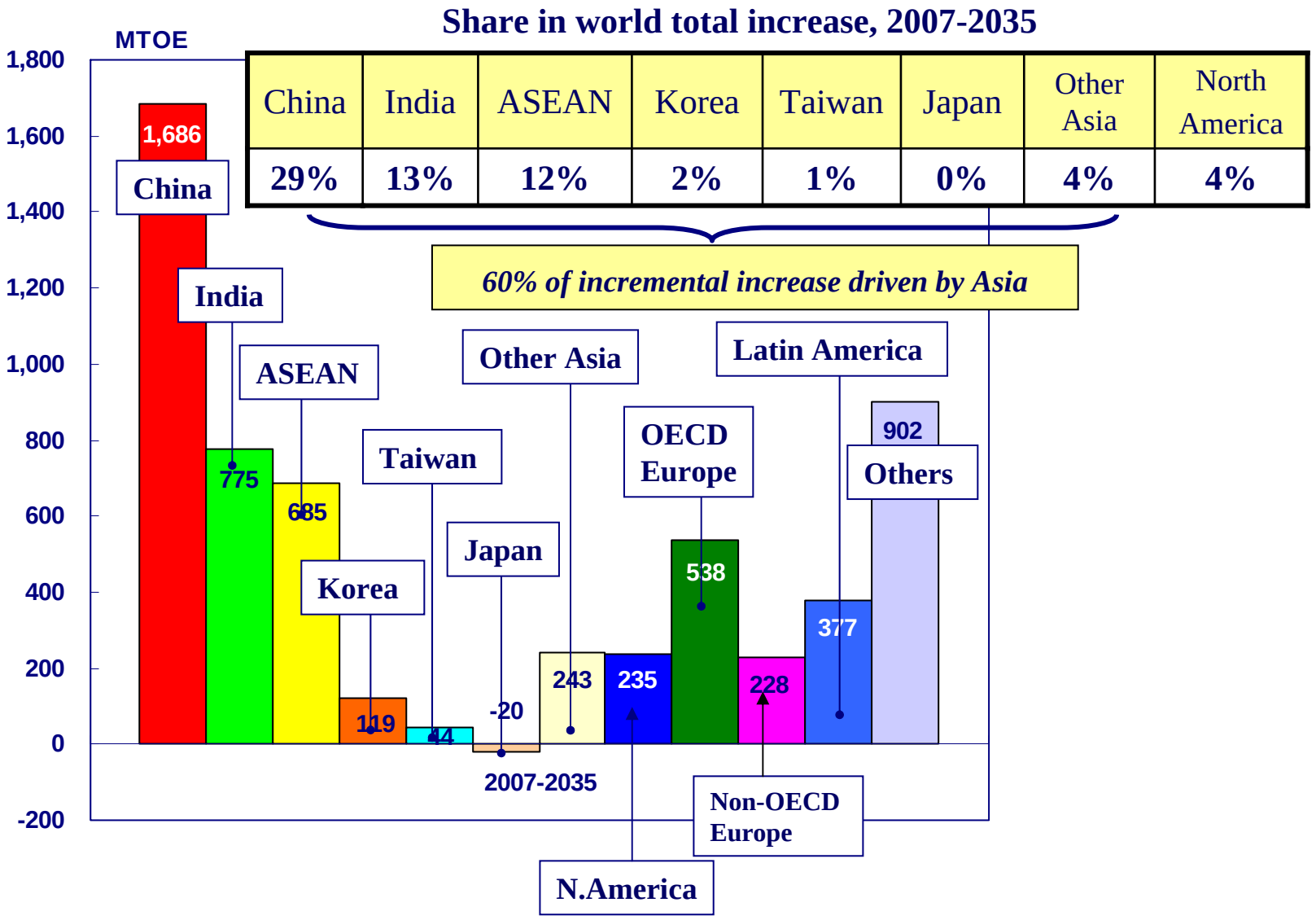
2007
11.1 billion toe
↓
2035
16.9 billion toe
(1.6-fold increase)

Asia

2007
3.6 billion toe
↓
2035
7.1 billion toe
(2.0-fold increase)

In 2035, primary energy demand of Asia will increase twice as much as current level, reflecting on highly economic growth. (3.6billion toe(2007) → 7.1 billion toe (2035))

Increase in World Primary Energy Demand by Region 2007-2035

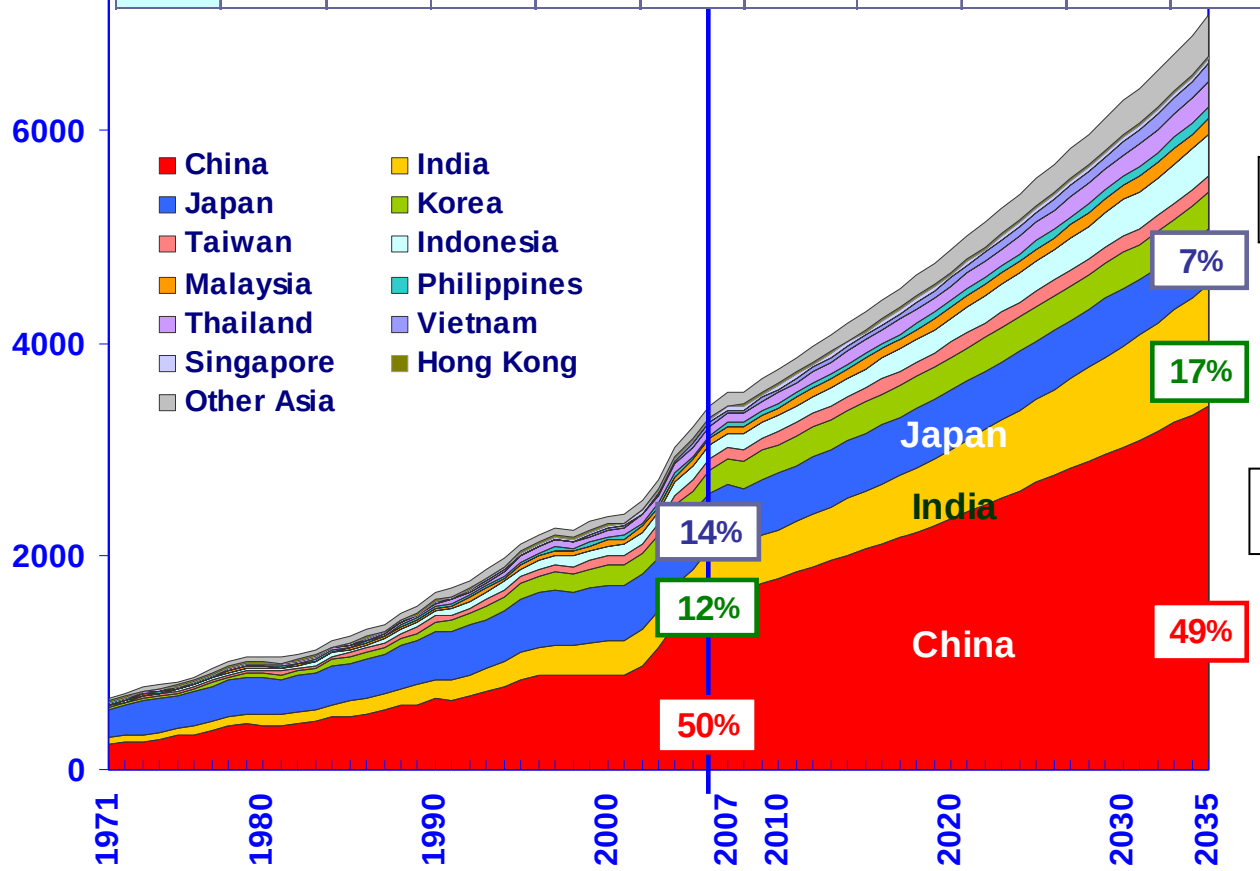


Approximately 60% of world increase is derived from Asia.

Primary Energy Demand by Region（Asia）

MTOE

AAGR	China	India	Japan	Korea	Taiwan	Singapore	Indonesia	Malaysia	Philippines	Thailand	Vietnam	Other Asia
1980-2007	5.5%	6.0%	1.5%	6.4%	5.2%	6.3%	6.4%	7.3%	3.4%	7.8%	7.7%	4.1%
2007-2035	2.4%	3.7%	-0.1%	1.5%	1.2%	1.9%	3.7%	2.6%	4.5%	3.6%	5.9%	4.2%



Asia

2007
3.6 billion toe
↓
2035
7.1 billion toe
(**2.0**-fold increase)

China

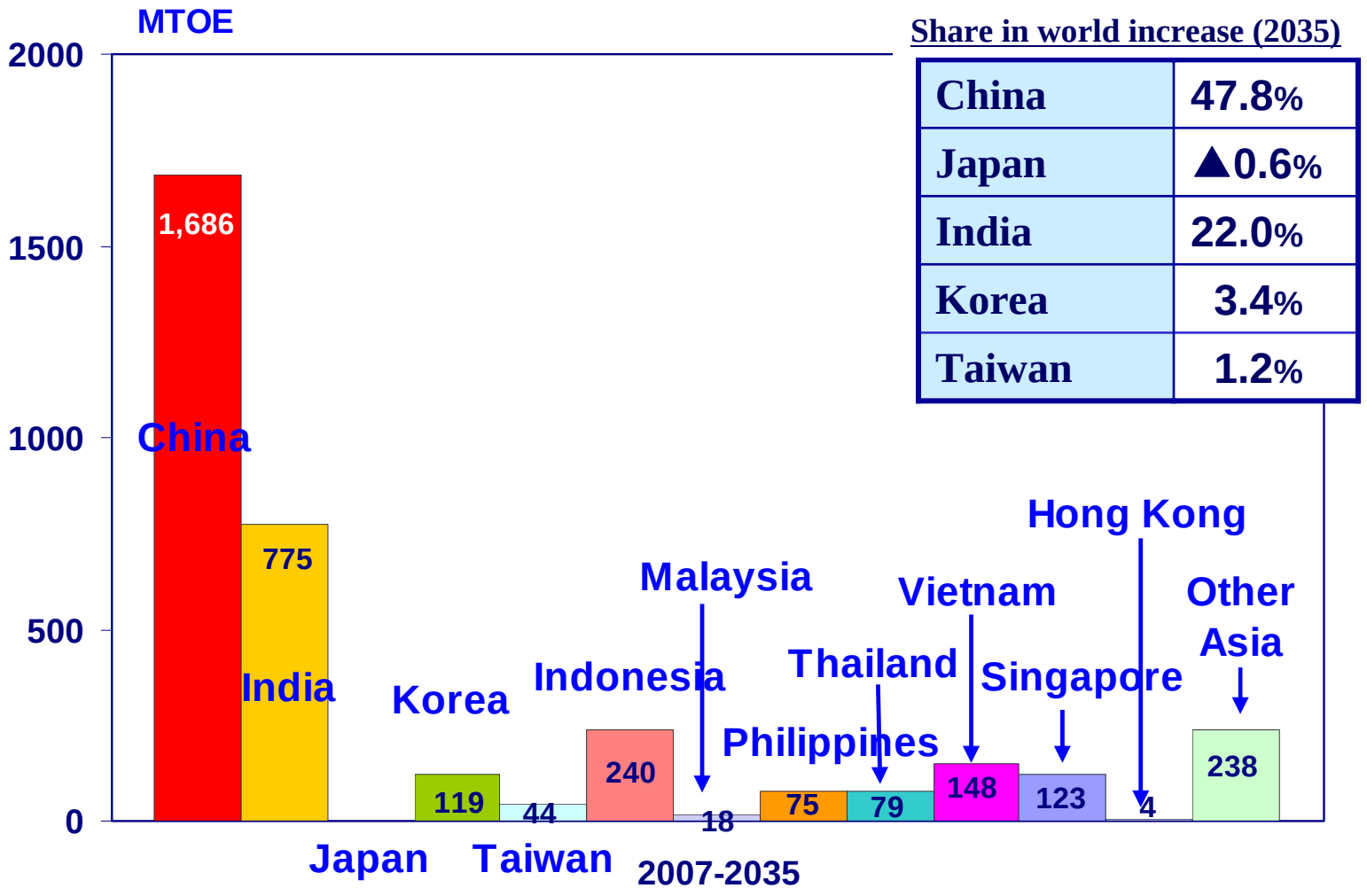
2007
1.8bil. toe
↓
2035
3.5bil. toe
(**2.0**-fold inc.)

India

2007
0.43bil. toe
↓
2035
1.2bil. toe
(**2.8**-fold inc.)

- *Based on strong economic growth of China and India, share of China and India in Asia significantly increase to 49% and 17% relatively.*
- *Japan's energy share in Asia will decline from 14% in 2007 to 7% in 2035 with its slower-paced economic growth and falling population.*

Increase in Asian Primary Energy Demand by Region, 2007-2035

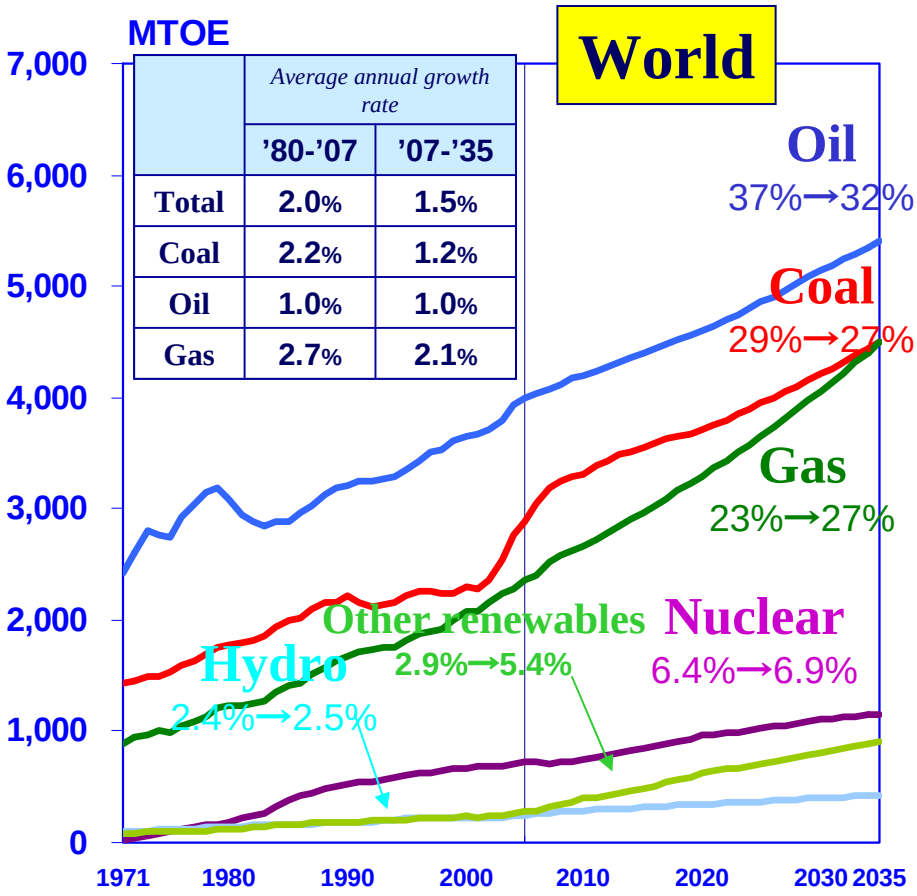


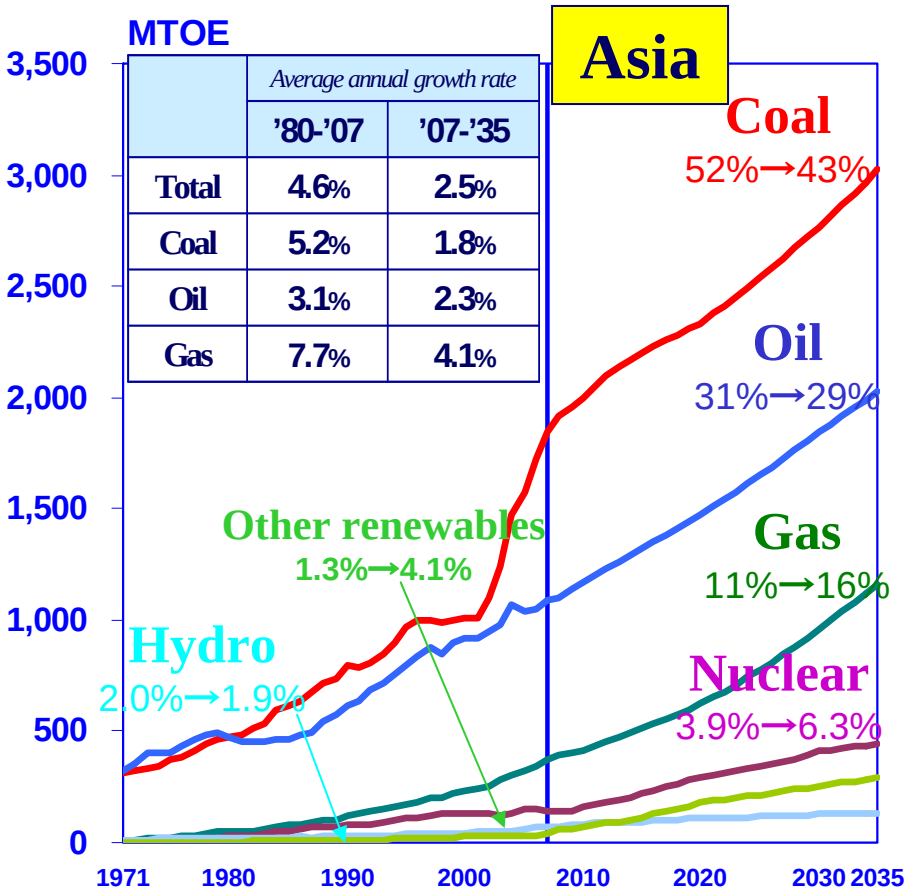
Share in world increase (2035)

China	47.8%
Japan	▲0.6%
India	22.0%
Korea	3.4%
Taiwan	1.2%

Of total increase in Asia, China and India, as prominent consumers, will account for approximately 70%.

Primary Energy Demand by Fuel（World / Asia ）

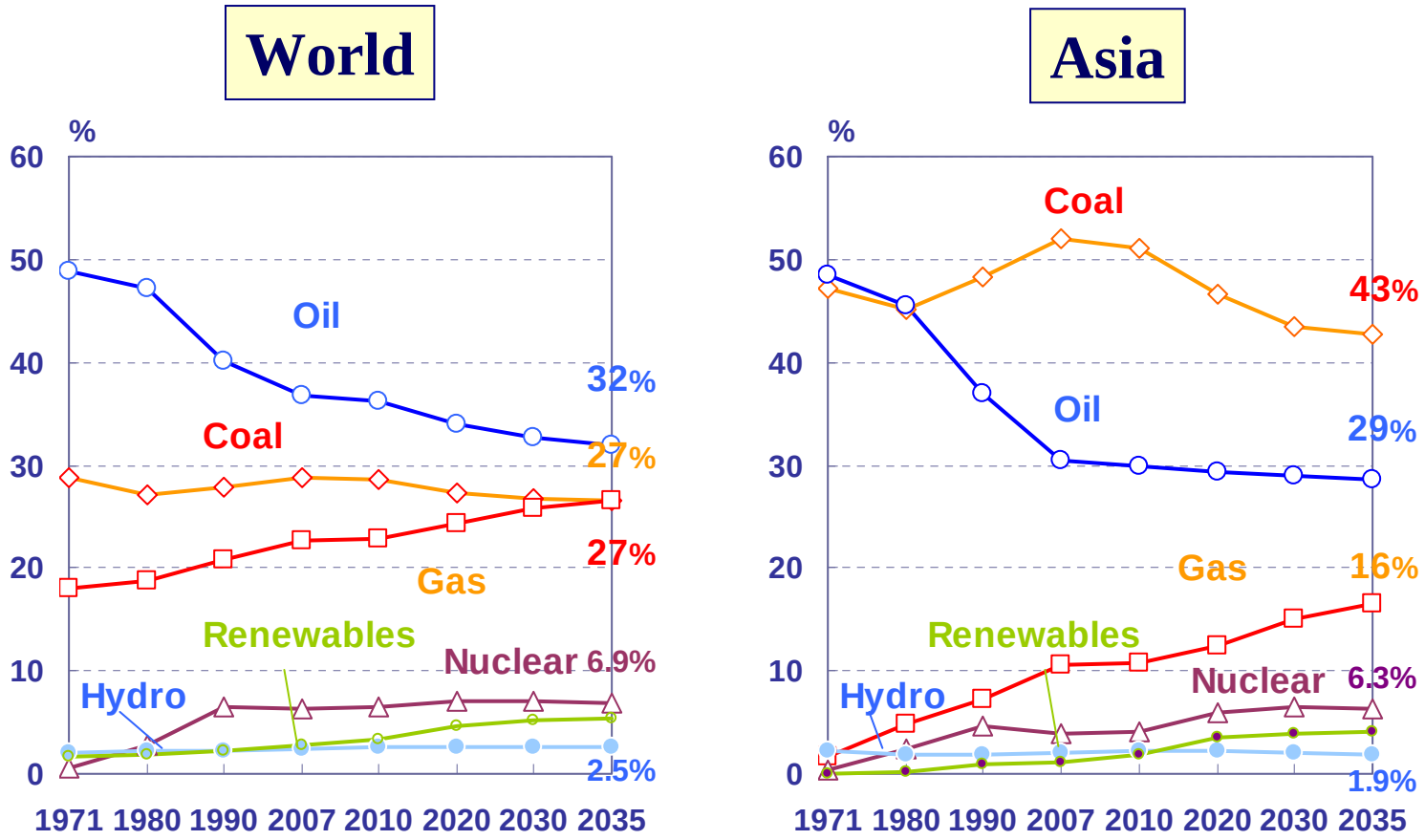




- Fossil energy namely Oil, Coal and Gas will continue to maintain its principal role over world energy demand (89% in 2007 →86% in 2035)

- Fossil energy especially coal will continue to maintain its principal role (Fossil energy; 94% in 2007 →88% in 2035)

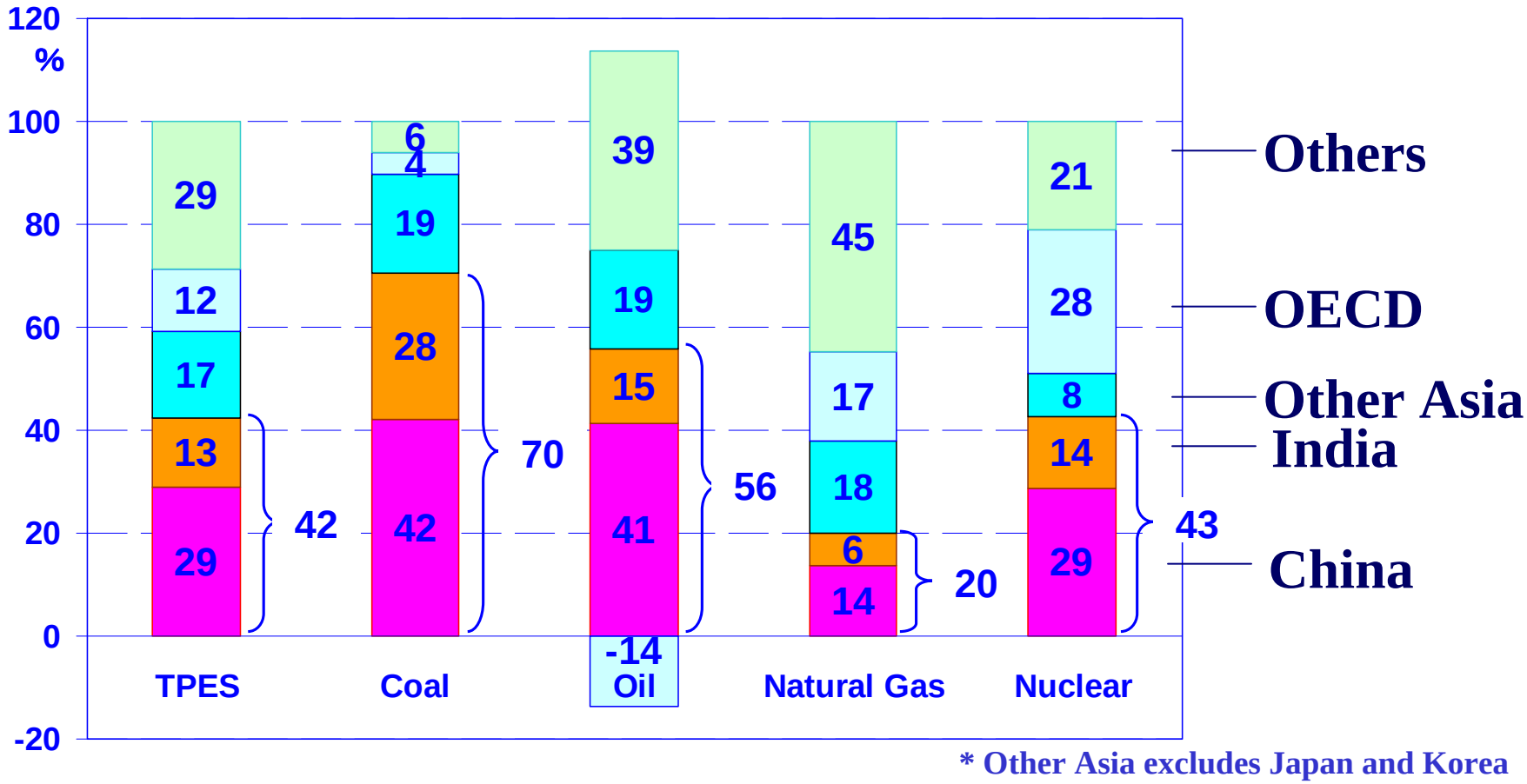
Comparison of Primary Energy Mix by Fuel



In Asia, coal remains the largest of primary energy due to increasing electricity demand toward 2035.(Coal share in Asia: 2007:52%→2030:43%)

Nuclear share in Asia gradually increases with active building-up of nuclear power plants in China, India, Japan and South Korea.

Increase in World Primary Energy by Fuel and by Region 2007-2035



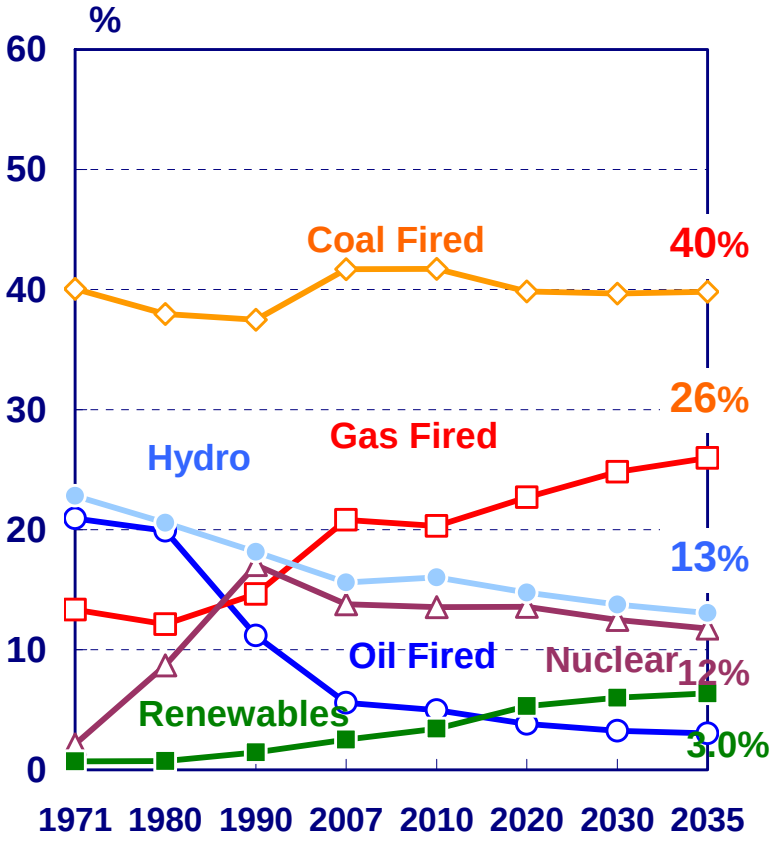
* Other Asia excludes Japan and Korea

Share of China and India in total world increase: TPES 42%,Coal 70%, Oil 56%, Nuclear 43%

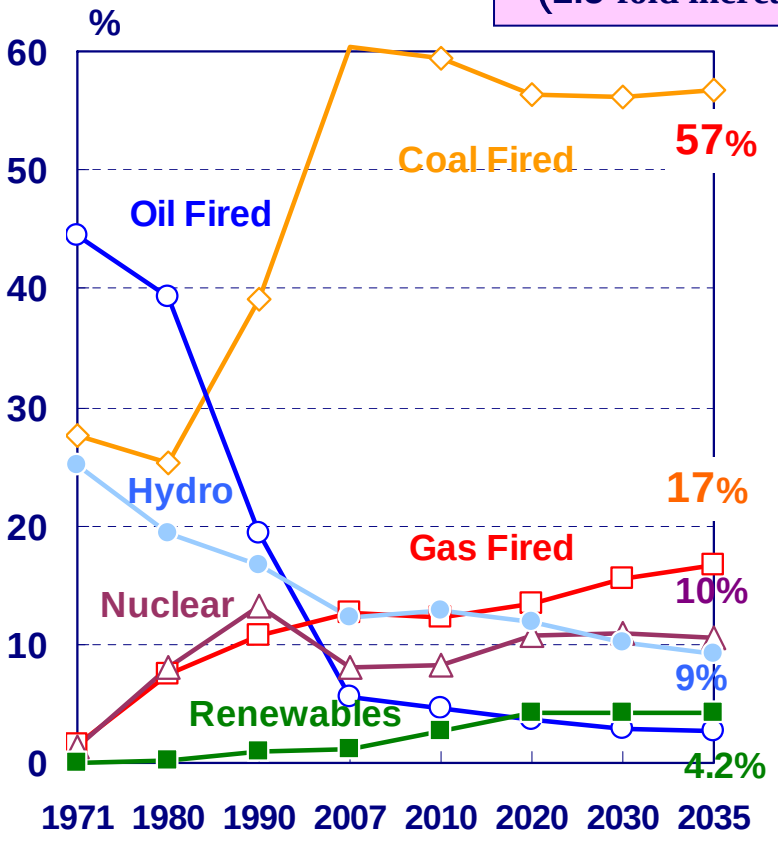
Power Generation Mix by Fuel, World and Asia

Electricity Demand
2007 6,650 TWh
↓
2035 16,460 TWh
(2.5-fold increase)

World



Asia

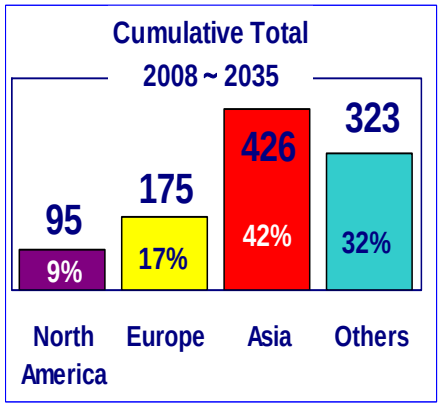


Asian region will cope with rapid growth of electricity demand mainly through installing coal-fired and gas-fired power generation plants

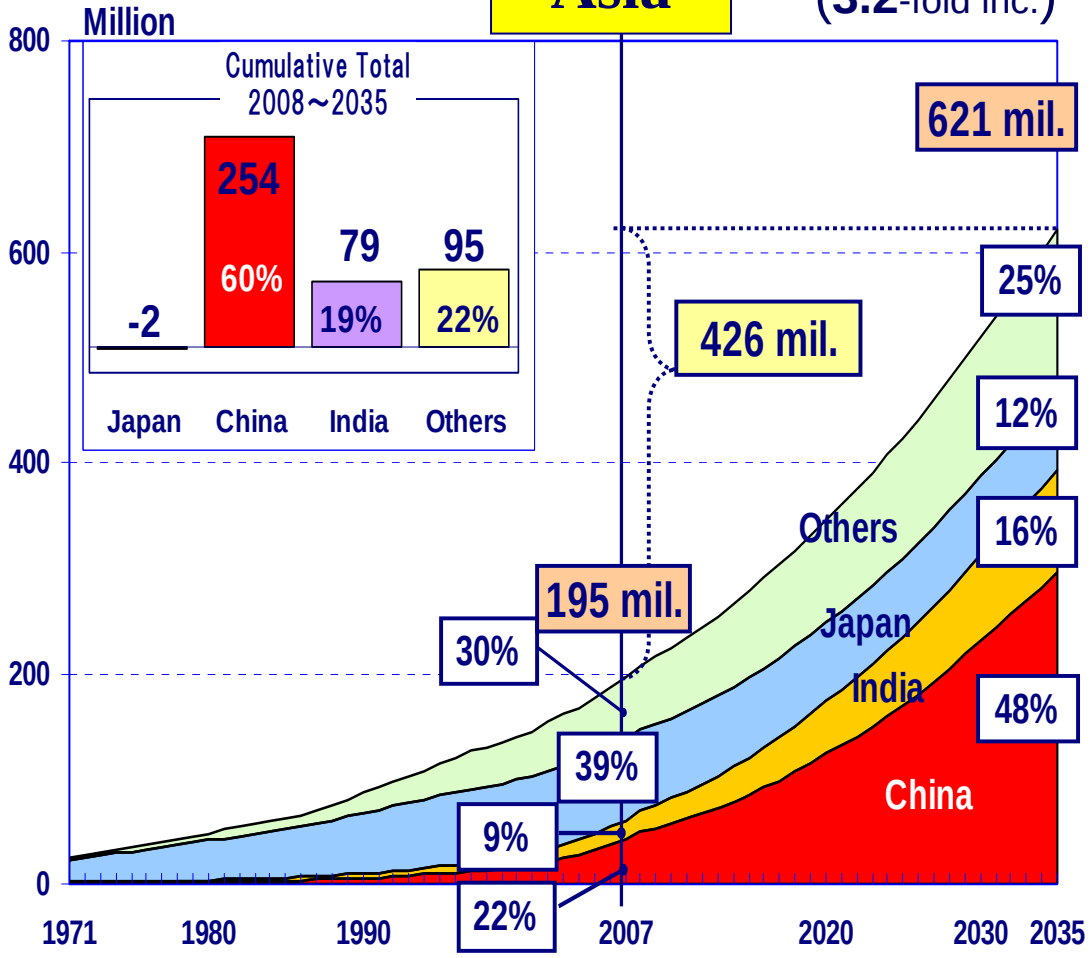
Vehicle Population

World

2007
0.95 bil.
↓
2035
2.0 bil.
(**2.0**-fold inc.)



Asia (**3.2**-fold inc.)



China

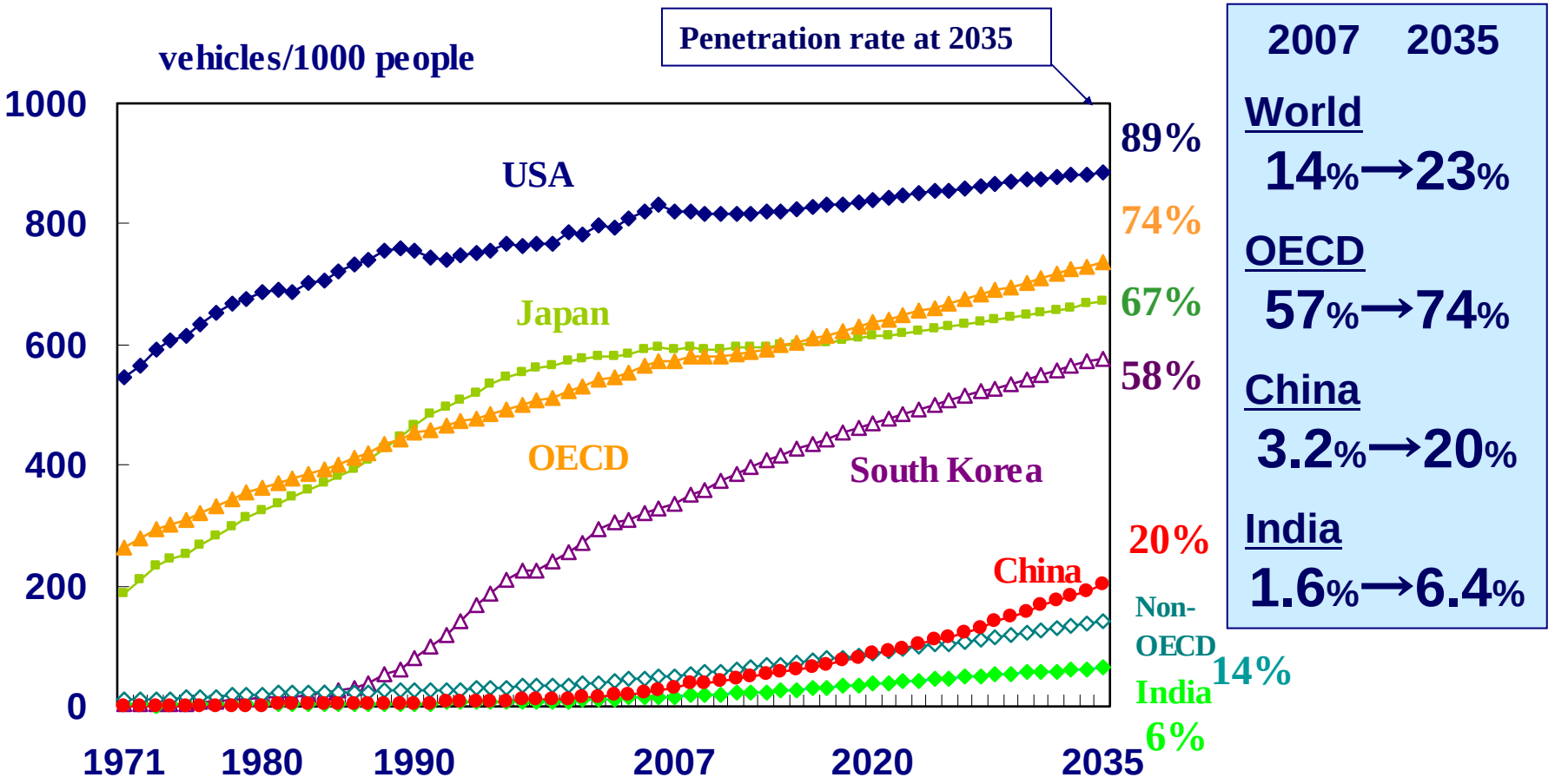
2007
42 mil.
↓
2035
296 mil.
(**7.0**-fold inc.)

India

2007
18 mil.
↓
2030
97 mil.
(**5.4**-fold inc.)

Approximately 40% of cumulative total vehicle population comes from Asia, with vehicle ownership increase in developed countries representing saturation trend.

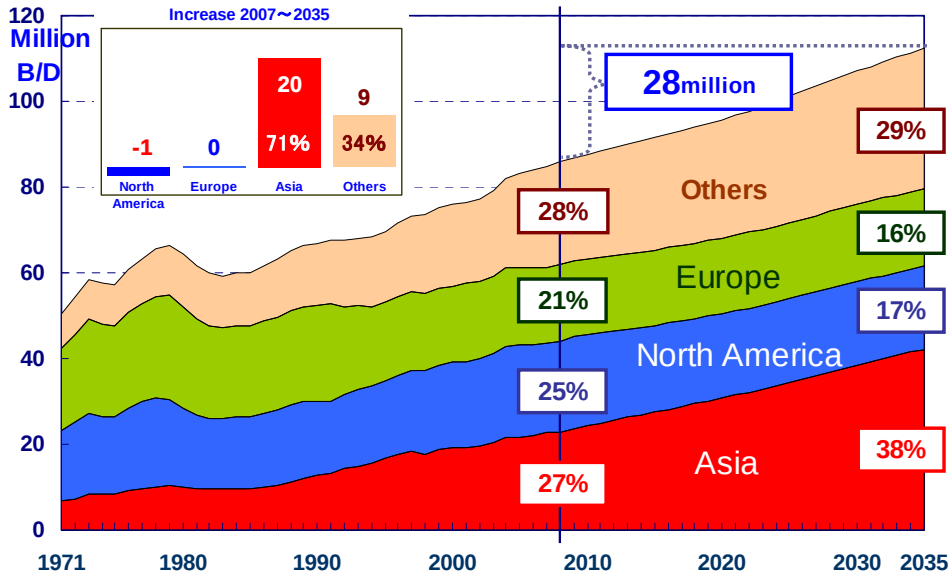
Vehicle Ownership Rate



Vehicle penetration will make progress mainly in Asian countries, the majority of which achieve higher economic growth.

Although vehicle ownership is projected to expand vigorously in China and India, the automobile ownership rate (diffusion rate)will still remain well below those of the developed countries.

Oil Demand ;World

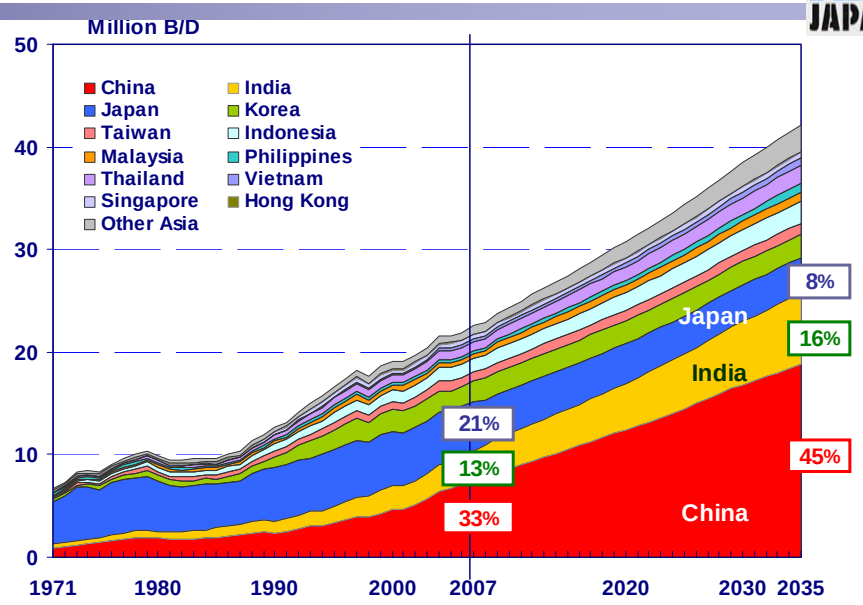


* Others include international banker fuel

2007
85 mb/d
↓
2035
113 mb/d

1.3-fold increase
(**28** mb/d growth)

Oil Demand ; Asia



AAGR	China	India	Japan	Korea	Taiwan	Singapore	Indonesia	Malaysia	Philippines	Thailand	Vietnam	Other Asia
1980-2007	5.3%	5.5%	-0.1%	—	3.1%	4.1%	4.0%	4.4%	—	—	—	5.1%
2007-2035	3.4%	3.1%	-1.2%	0.5%	0.6%	0.8%	2.0%	1.8%	4.0%	2.6%	3.4%	4.3%

2007
23 mb/d
↓
2035
42 mb/d

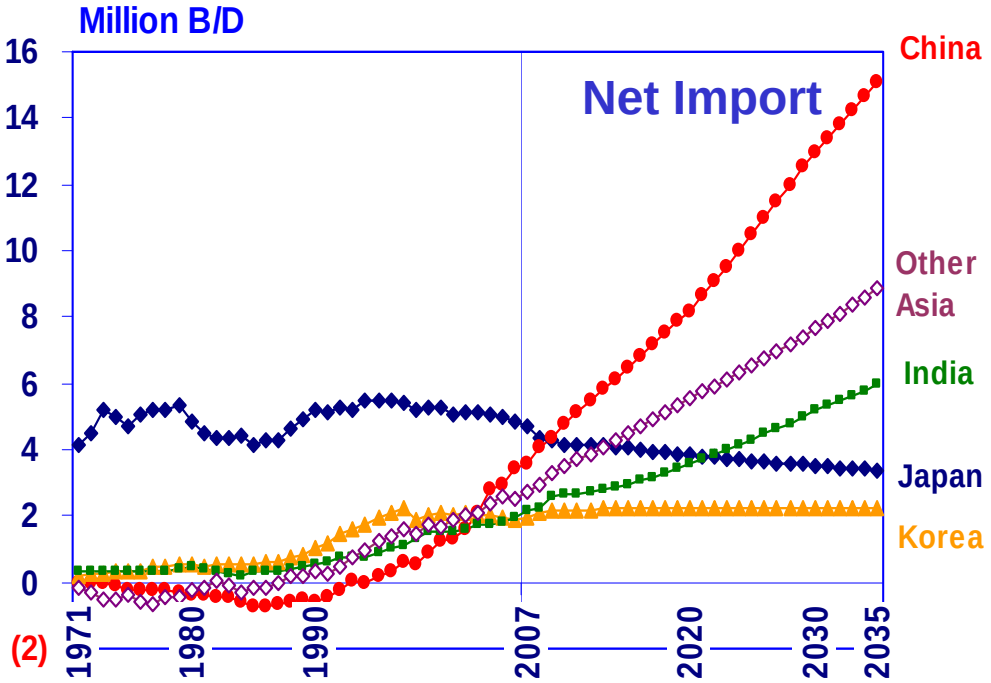
1.9-fold increase
(**20** mb/d growth)

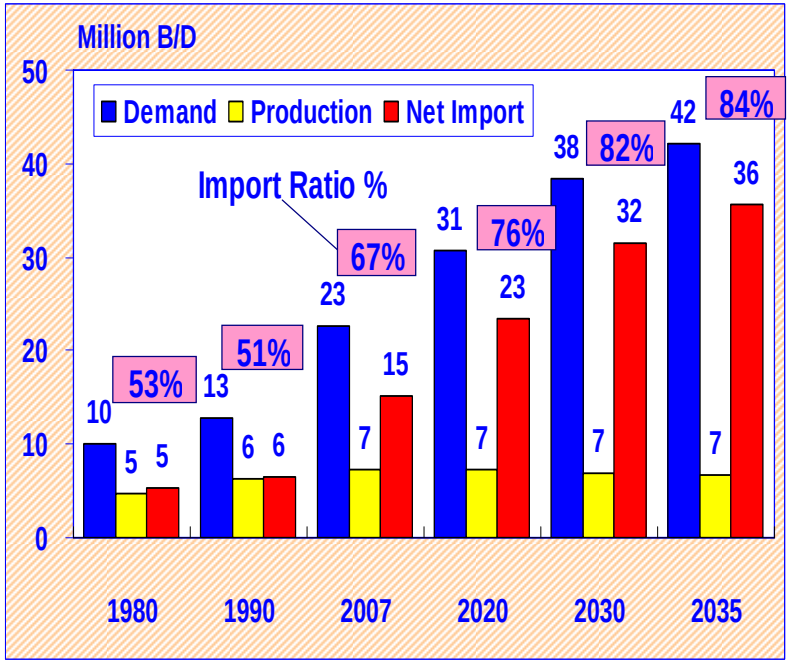
	2007	2035
China	7.4 mb/d	18.8 mb/d
Japan	4.8 mb/d	3.4 mb/d
India	2.9 mb/d	7.0 mb/d

Oil demand in China will boost from 7.4 million B/D in 2007 to 18.8 million B/D in 2035, due mainly to its increasing vehicle stock.

The oil demand share of China and India in Asia will grow from 46% in 2007to 61% in 2035.

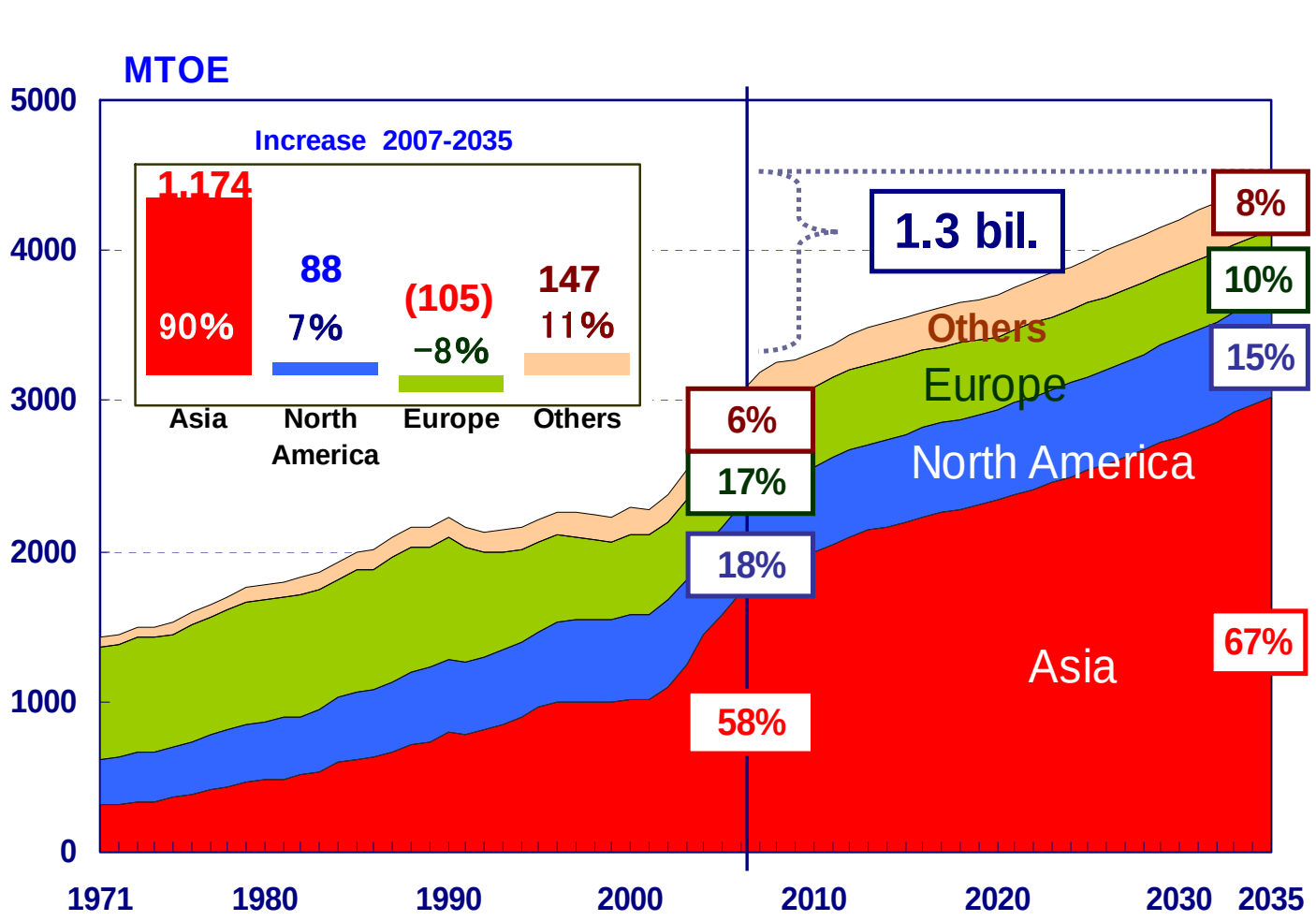
Outlook for Net Oil Imports in Asia





China became a net import country in 1993. The amount of oil import is projected to grow from 3.6 million B/D in 2007 to 15.1 million B/D (4.2-fold increase) in 2035 reflecting expansion of demand mainly by growth of vehicle ownership and by stagnation of domestic oil production due to the aging of main oil fields such as Daqing and Shengli.

Coal Demand by Region ; World



World

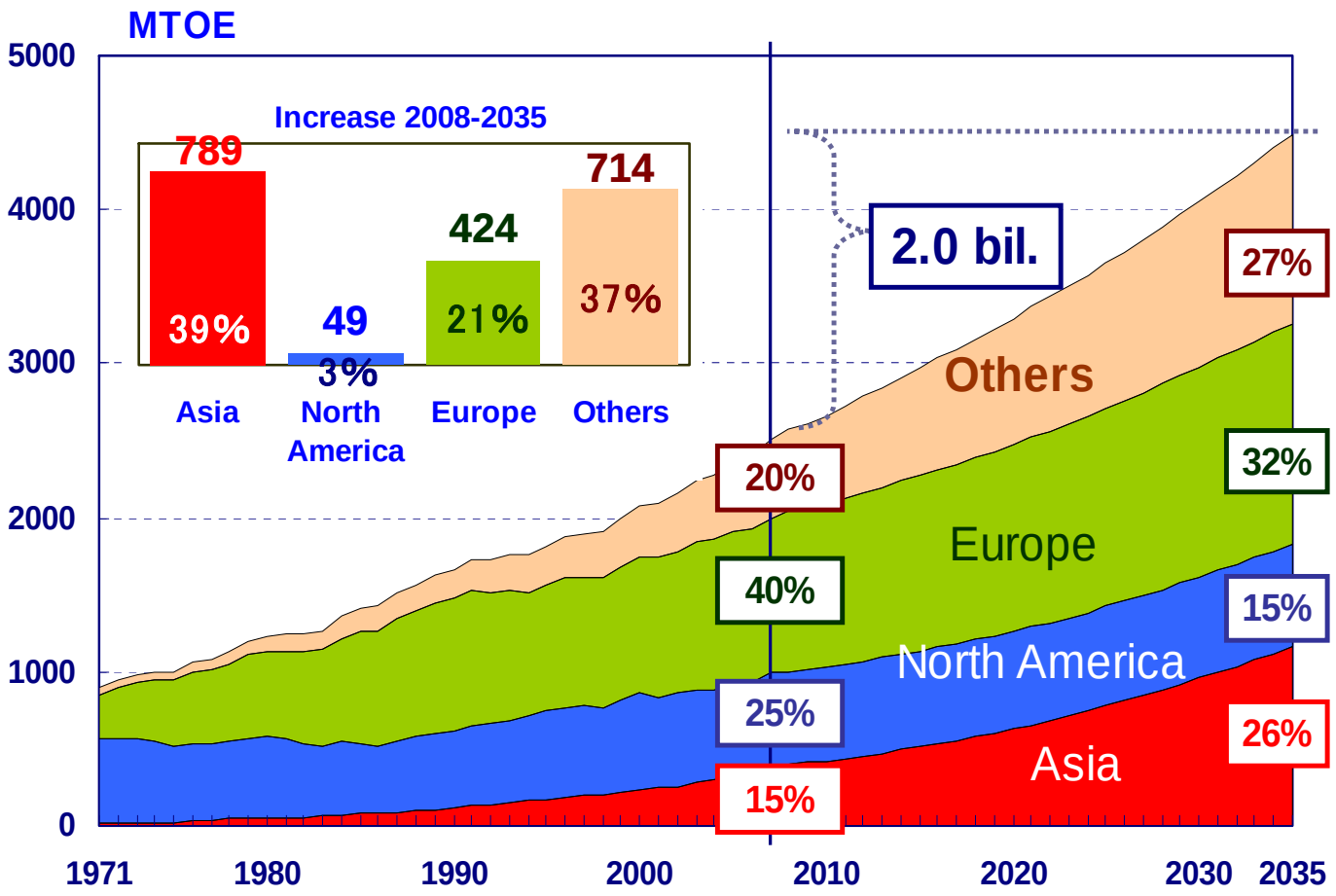
2007
3.19 billion toe
↓
2035
4.49 billion toe

Asia

2007
1.85 billion toe
↓
2035
3.02 billion toe

World coal demand will increase by 1.4-fold from 3.19 billion ton in 2007 to 4.49 billion ton in 2035.

Gas Demand by Region ; World



2007
2.51 billion toe
(2.79 trillion m³)
(2.0 bil. tons LNG)
↓
2035
4.49 billion toe
(4.99 trillion m³)
(3.7 bil. tons LNG)

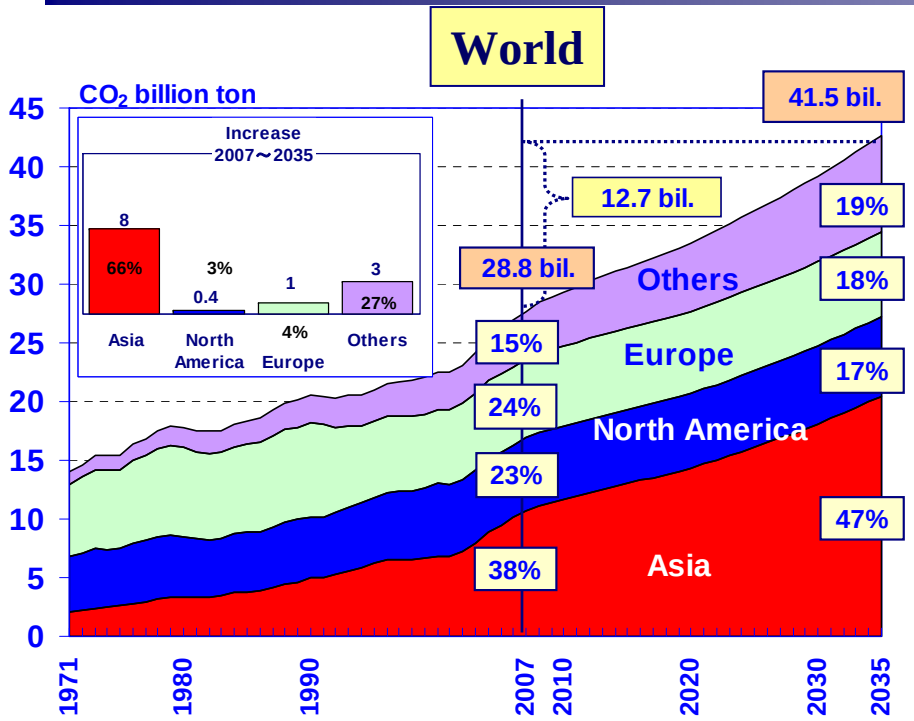
Asia

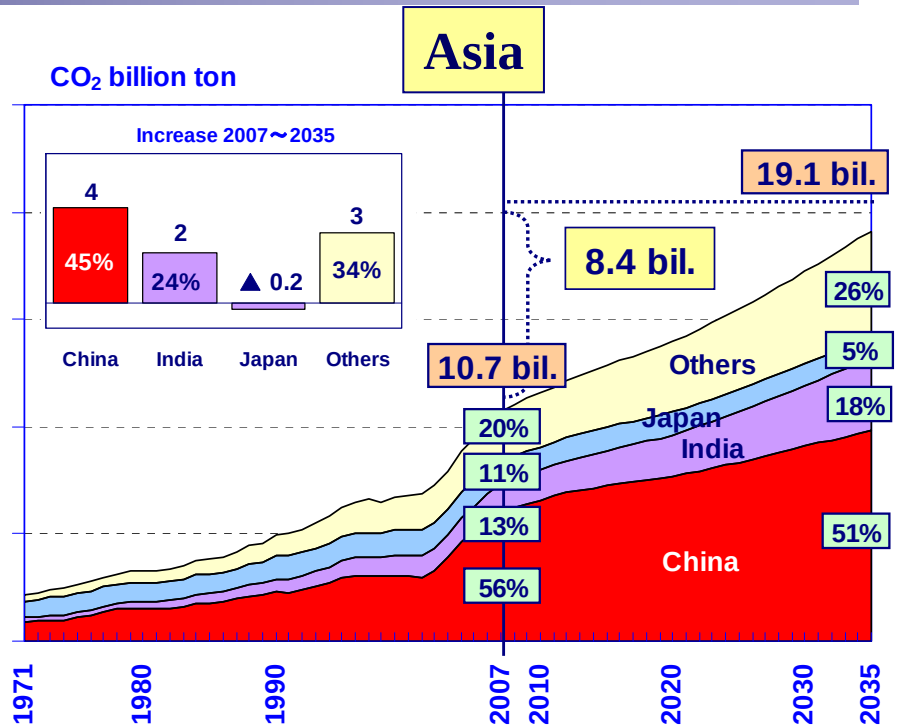
2007
0.38 billion toe
(0.31 bil. tons LNG)
↓
2035
1.17 billion toe
(0.95 bil. tons LNG)

World gas demand will increase by 1.9-fold from 2,790 bcm in 2007 to 4,990 bcm in 2035.

Asia's gas demand will increase by 3.1-fold from 420 bcm in 2007 to 1,290 bcm in 2035.

CO_2 Emissions





World

2007
28.8 billion
↓
2035
41.5 billion
(**1.4**-fold growth)

Asia

2007
10.7 billion
↓
2035
19.1 billion
(**1.8**-fold growth)

China

2007
6.0 billion
↓
2035
9.8 billion
(**1.6**–fold growth)

India

2007
1.4 billion
↓
2035
3.4 billion
(**2.5**–fold growth)

Increase in Asia will account for 66% in the world .

CO2 emissions of China and India will steadily increase driven by coal consumption. The share together accounts for 70% in Asia.

Advanced Technology Case

In Advanced Technology scenario, each country is expected to implement various energy and environmental policy to secure energy supply and mitigate carbon dioxide emissions These policies are reflecting on actual policy under consideration in each country. In those countries where concrete energy policies do not exist, improvement of energy efficiency is assumed to develop more rapidly than the Reference case owing to technology transfer from developed countries.

Assumed measures：

■Energy conservation in industry and residential/commercial sector

High efficiency boiler、Coke Dry Quenching equipment(CDQ)、Top Gas Pressure Recovery Turbine(TRT)、IT-based energy management system、Thermal insulation、High efficiency heat pump etc.

■Energy-efficiency in transport sector

Hybrid-vehicle、ITS(Intelligent Transport System) etc.

■Renewables

Bio-fuel for automobile, photovoltaic, Wind-power, Biomass power generation etc.

■Nuclear

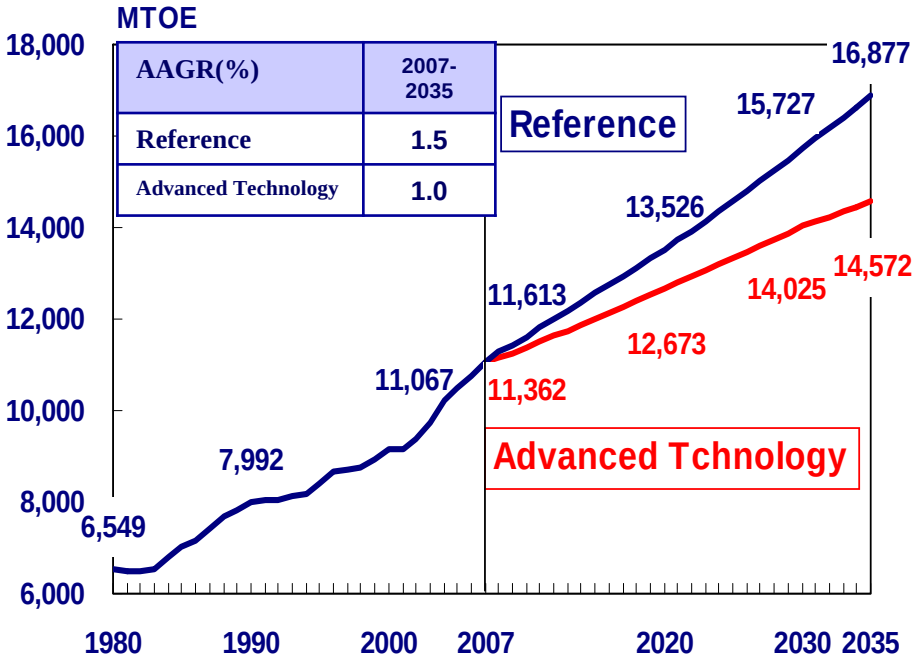
Building new nuclear power plant、enhancement of operating ratio and safety control etc.

■Energy-efficiency in power generation sector

Coal-fired IGCC/IGFC、Gas-fired MACC（More Advanced Combined Cycle, 1,500℃ class）, etc.

Primary Energy Demand

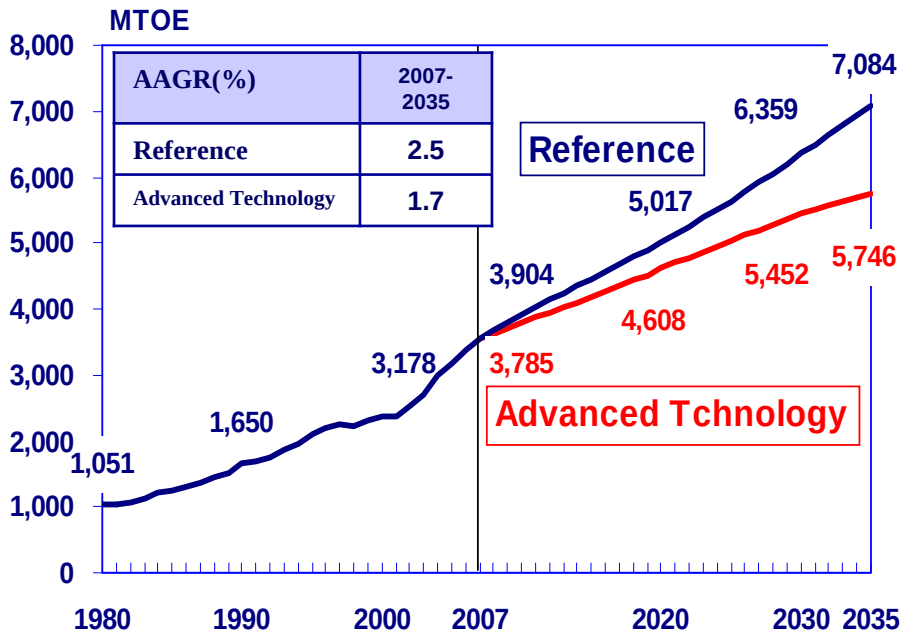
World



2,310MTOE (▲14%)

In 2035, primary energy demand is reduced by around 14% (2,310 Mtoe)

Asia

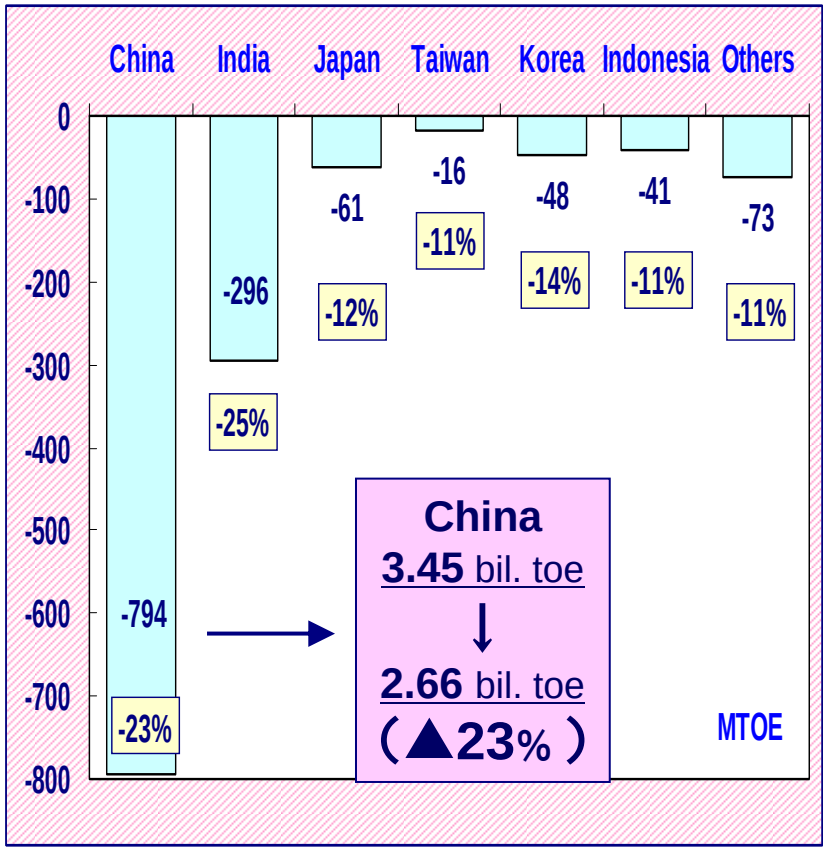


1,340MTOE (▲19%)

In 2035, primary energy demand is reduced by around 19% (1,340 Mtoe)

Change in Total Primary Energy & Oil Demand (Asia)

【 Change in TPE in 2035 】



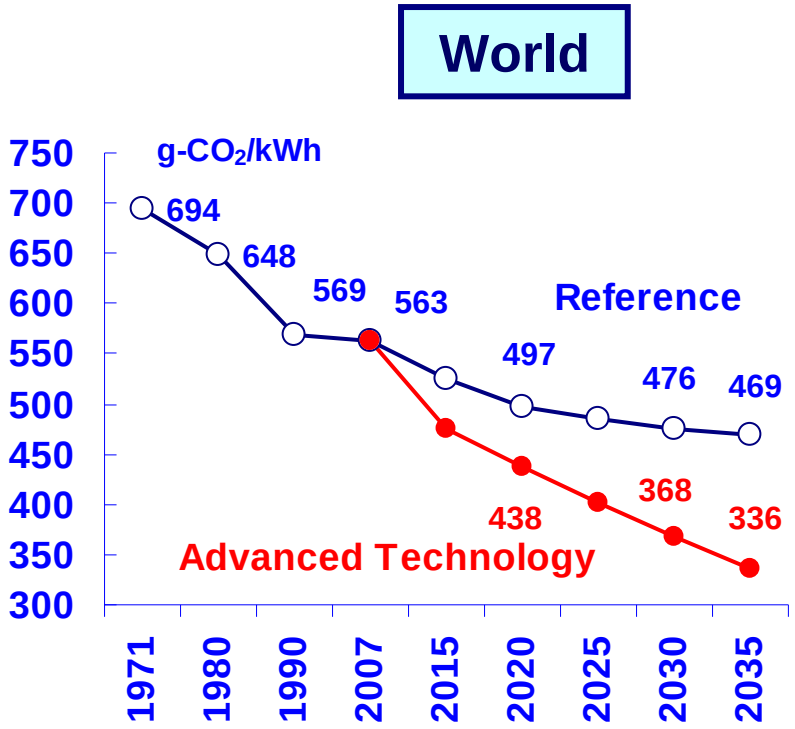
【 Change in Oil Demand in 2035 】

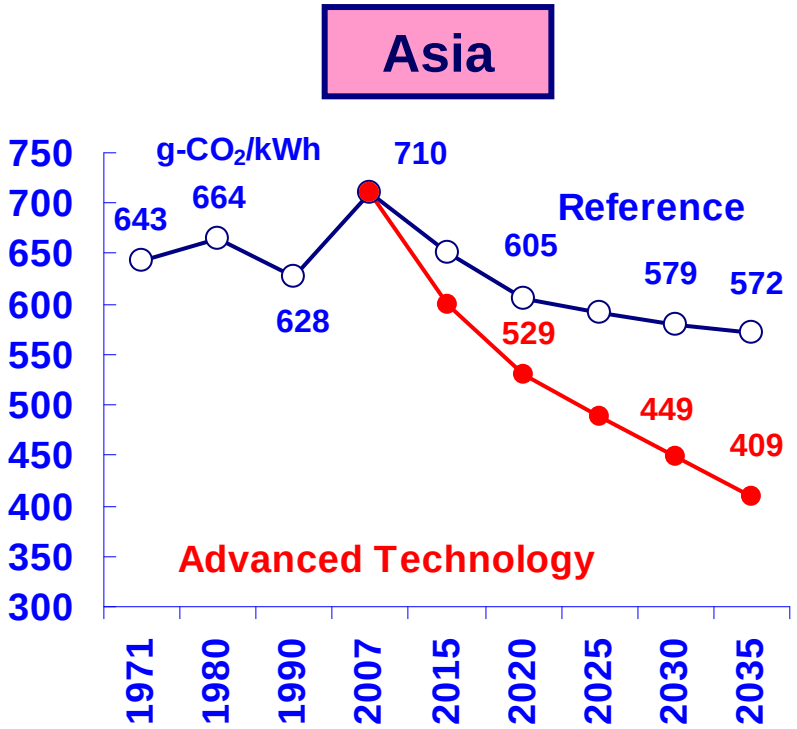
Million B/D	2007 (actual)	2035		
		Reference	Advanced Technology	Reduction
China	7.4	18.8	13.6	5.2
East Asia	14.2	24.5	18.5	5.9
Asia	22.6	42.2	34.9	7.3
World	85.0	112.5	98.1	14.4

Potential of energy conservation is large in both China and India through enhancing energy consumption efficiency

CO_2 Intensity of Power Generation

*Intensity at Power Generation Unit End

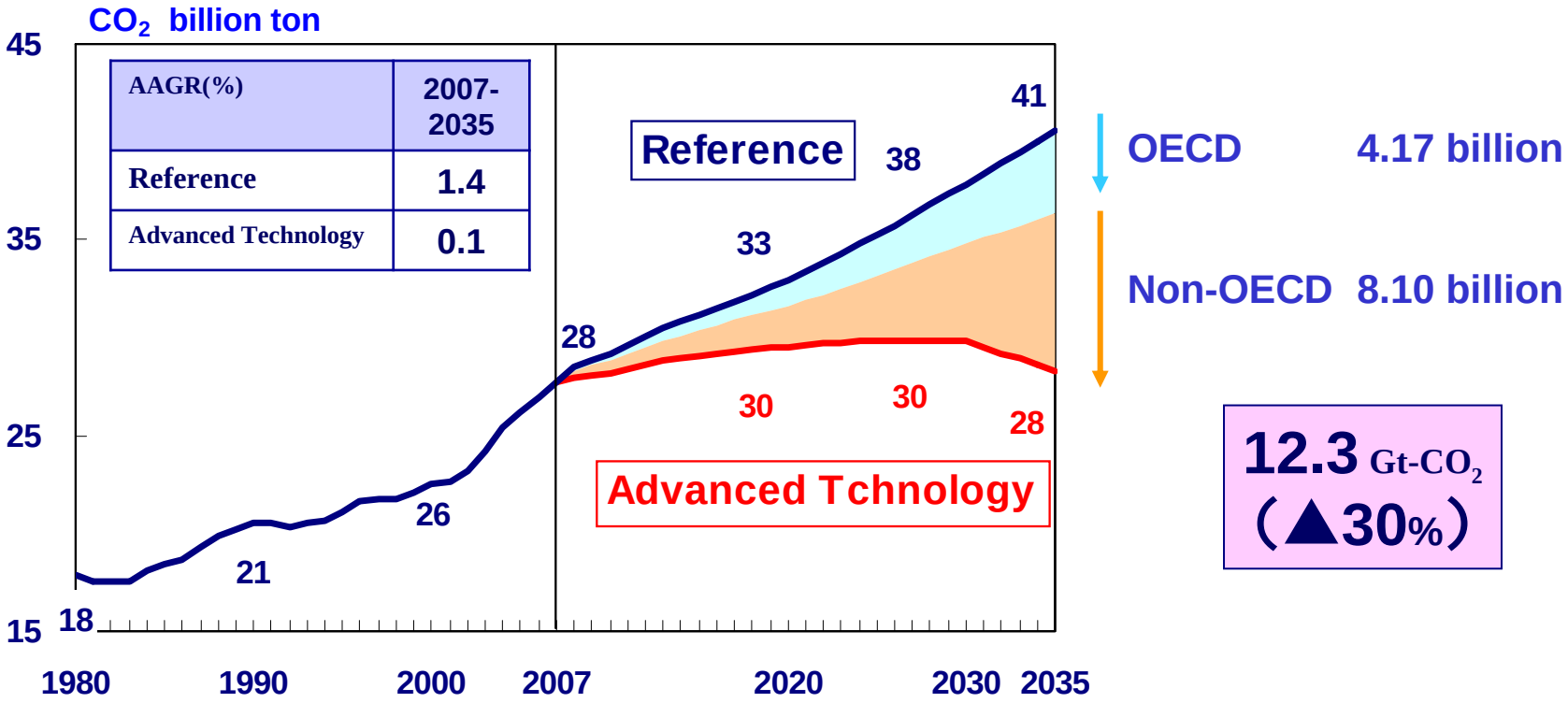




Japan ; 420g-CO2/kWh (2007)

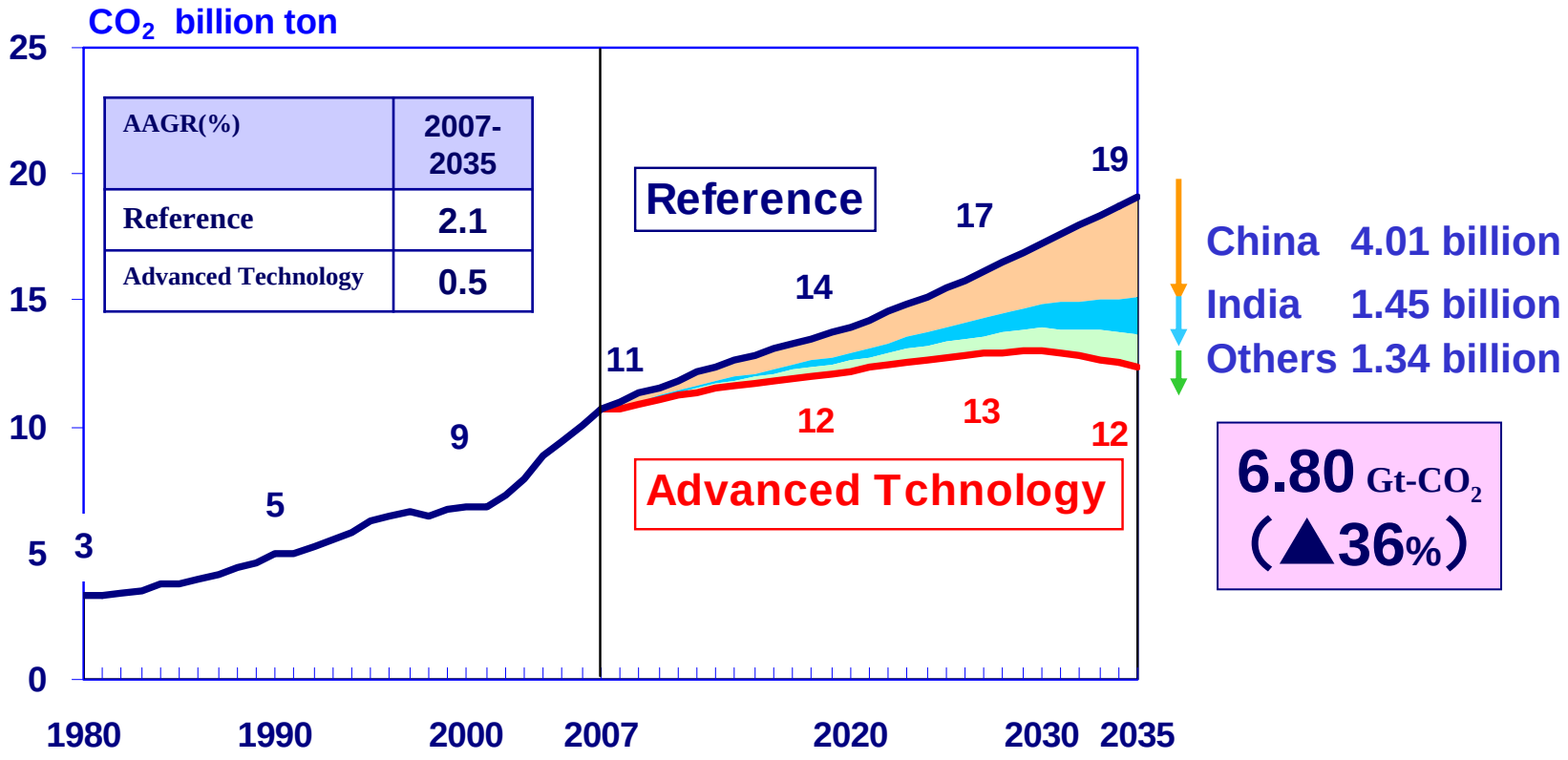
-Introduction of Nuclear, Renewables and High Efficiency Power Plants (Clean Coal Technology, MACC etc.) will significantly improve CO2 intensity
-Reference Case ; 17% (World)、19% (Asia) vs 2007
-Advanced Technology Case ; 40% (World)、42% (Asia) vs 2007

CO_2 Emissions (World)



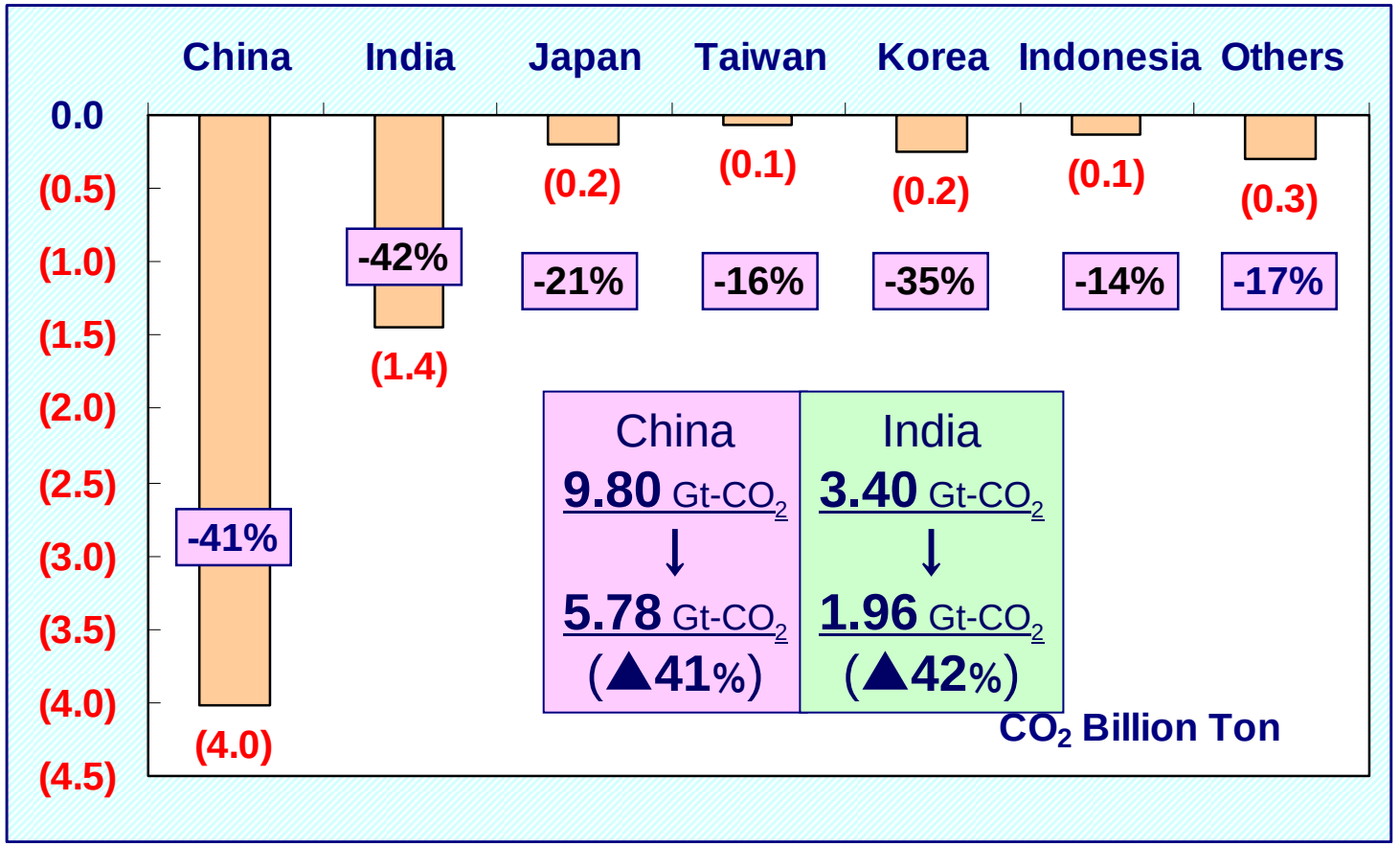
In 2035, mitigation (reduction) of CO_2 emissions is achieved by about 30%(12.3 Gt-CO_2) roughly equivalent to the emissions of OECD countries (12.8 Gt) in 2007

CO_2 Emissions (Asia)



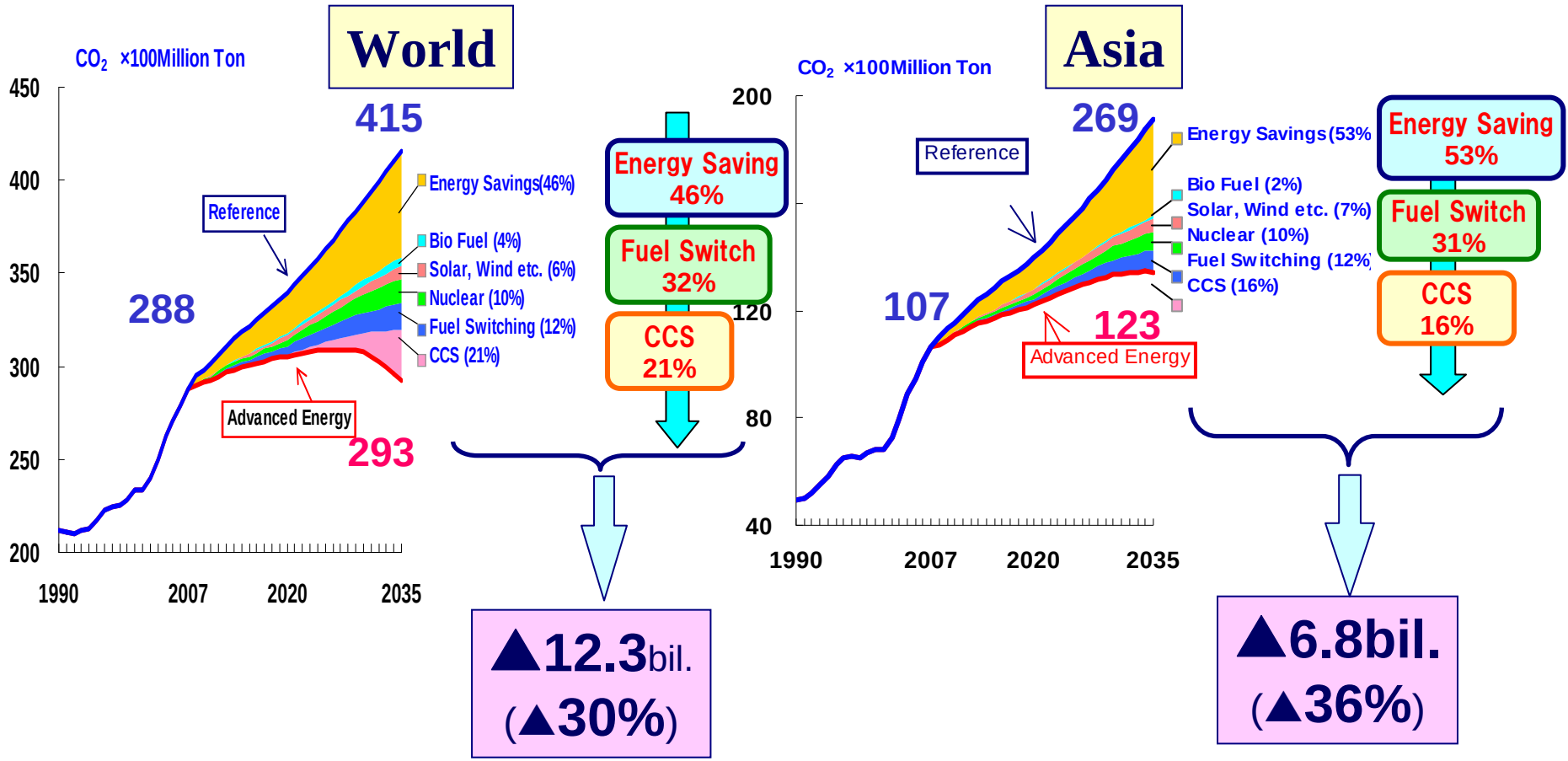
In 2035, mitigation of CO_2 emissions is achieved by about 36%(6.80 Gt-CO_2) roughly equivalent to the emissions of China (5.98 Gt) plus Japan (1.22 Gt) in 2007

CO_2 Emissions (Asia) 【 Change of CO_2 in 2035 】



Through the introduction of higher efficient and more environmentally compatible technology, CO2 emissions will be substantially mitigated in China and India
CO2 mitigation of about 4.0 Gt in China and 1.4 Gt in India correspond to 4.2 times and 1.5 times of current Japan's emissions (0.96 Gt in 2007) respectively

Mitigation of CO_2 Emissions by counter measures



There are many kinds of counter measures toward mitigation of CO_2 emissions. Though energy saving effort is most effective, combined effort with another measures make huge contribution to reduce energy consumption and GHG emissions.

Implications

＜Enhancement of Energy Security in Asia ＞

Import dependency of oil in Asia will substantially increase from 68% in 2007 to 84% in 2035, reflecting on the stagnation of regional crude oil production and rapid oil demand growth based on boosting vehicle ownership. Combined with the expectation of rise in oil price, the higher oil import dependency may affect the economy of several regional member countries. Since stable energy supply means an integral part of economic development, the various measures both at the short-term and long-term may need to be implemented. Given the diversify in energy resources endowment, economic development levels and energy demand structure of Asia, intraregional energy trade, investment and technology transfer would be effective for improving energy security.

＜Response to Global Environmental Problems＞

Rapid increase in CO2 emissions in Asian countries underscores that a far larger overall cost-benefit would be delivered by mitigation of environmental load through transfer of technology.

China, India and other developing Asian countries have immense potential for energy conservation. These countries offer enormous margin for technical assistance through the Clean Development Mechanism (CDM) and other schemes.

Implications

＜Pursuit of Energy “Best Mix”＞

Coal: *In Asia, coal consumption will increase mainly in power sector. Since coal utilization entails a high environmental load, it is necessary to promote highly efficient and environmentally compatible use through developing “Clean Coal Technology”.*

Nuclear: *Nuclear power generation will play a major role in ensuring a stable supply of electricity and in overcoming environmental problems. It is important that we should increase the share of nuclear power generation, seeing it as a core source of energy supply.*

Renewables: *Most renewables are indigenous resources. Moreover, renewables constitute an important option for mitigating global warming. We should ensure wider use of renewables by reinforcing the implementation of effective and efficient measures for promoting their use and by introducing policies in support of technological innovations.*

Thank you for your attention

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<Appendix>

Basic Framework

MACRO Economic Model†

- GDP components
- Price/Labor etc.
- Activities: Industry/ Transport

GDP, Crude oil price, Exchange rate, Population, Nuclear/Hydro Power generation facilities, World trade etc.

† Country-specific macro economic model for China, Korea and ASEAN 4 countries (Indonesia, Malaysia, Philippines, Thailand)

Energy Demand-Supply Model

World Trading Model of Crude Oil and Petroleum Products (LP Optimization)

- Energy Demand
- Conversion Sector
- Energy Supply
- CO_2 Emissions

Technology Evaluation Model (Vehicles, Consumer Electric Applications etc.

These models provide fully understanding of the interaction among numerous parameters in a logical and consistent way.

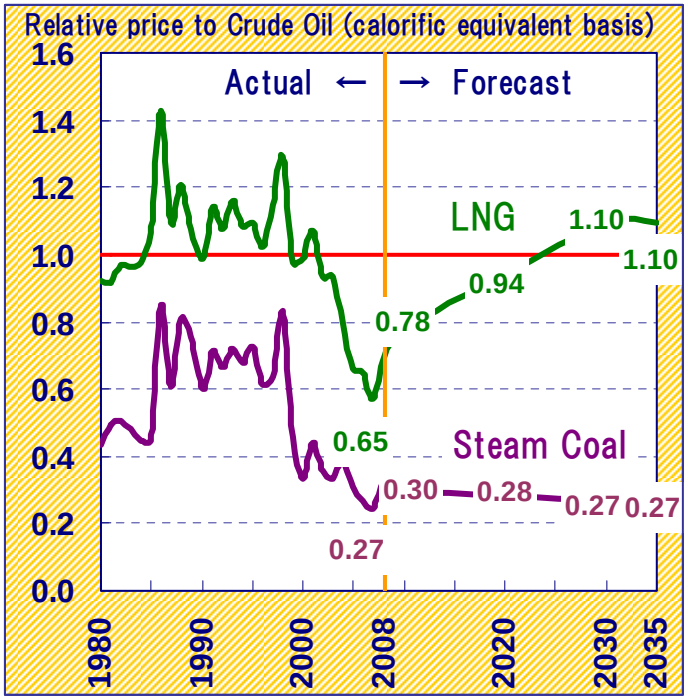
Primary Energy Price

【Real and Nominal Prices】

		2000	2008	2010	2020	2030	2035
Crude Oil	**Real Price**	**32**	**103**	**67**	**95**	**109**	**117**
$/bbl	nominal price	28	103	70	121	169	200
LNG	**Real Price**	**282**	**647**	**467**	**805**	**1,075**	**1,150**
$/t	nominal price	251	647	486	1,021	1,661	1,963
Steam Coal	**Real Price**	**39**	**125**	**74**	**101**	**110**	**117**
$/t	nominal price	35	125	77	128	169	200

** Real prices are set in 2008.*
** Inflation rates are assumed at 2% annually.*

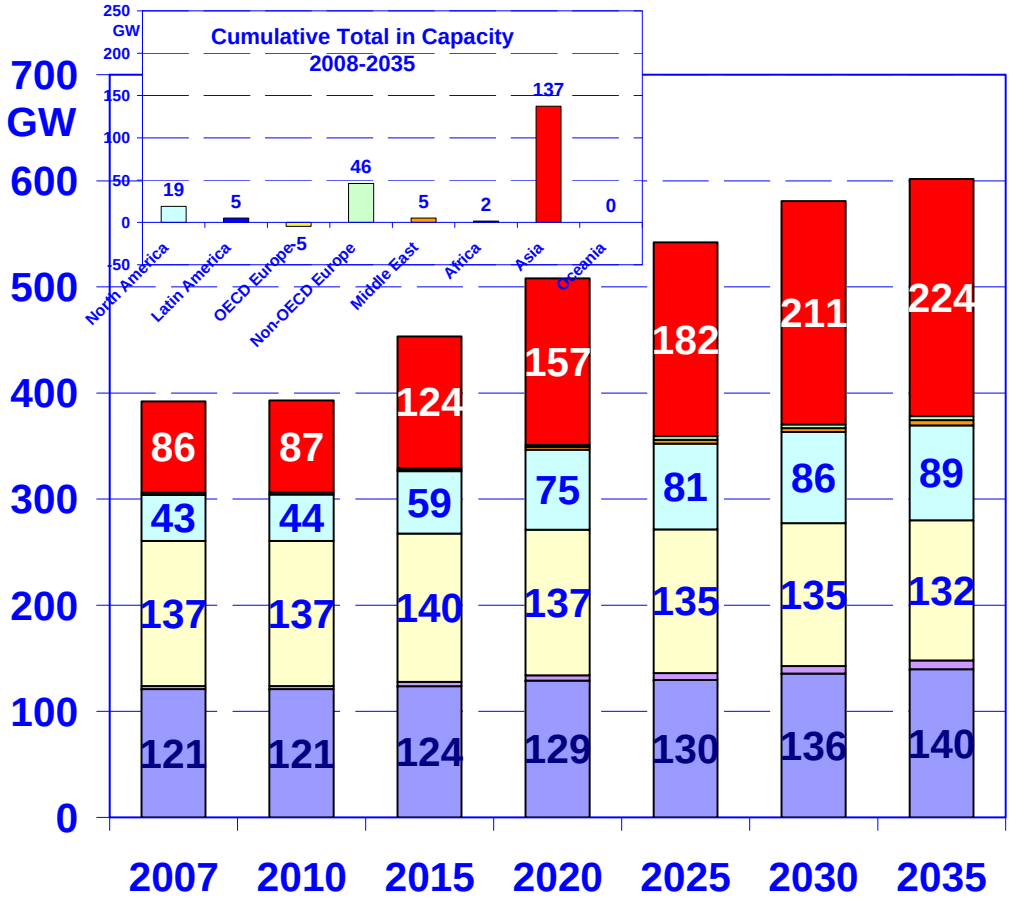
【Relative prices to Crude Oil】



▪Currently, LNG price is cheaper compared with sharply rising petroleum price. For the long-term trend, the gap between crude oil and LNG will become smaller and the price of LNG will become higher than crude oil in 2030.

▪Coal relative price will remain roughly the same toward 2035.

Nuclear Capacity ; World



Oceania
Asia
Africa
Middle East
Non-OECD Europe
OECD Europe
Latin America
North America

World

2007
392GW
↓
2035
602GW
(1.6-fold increase)

Asia

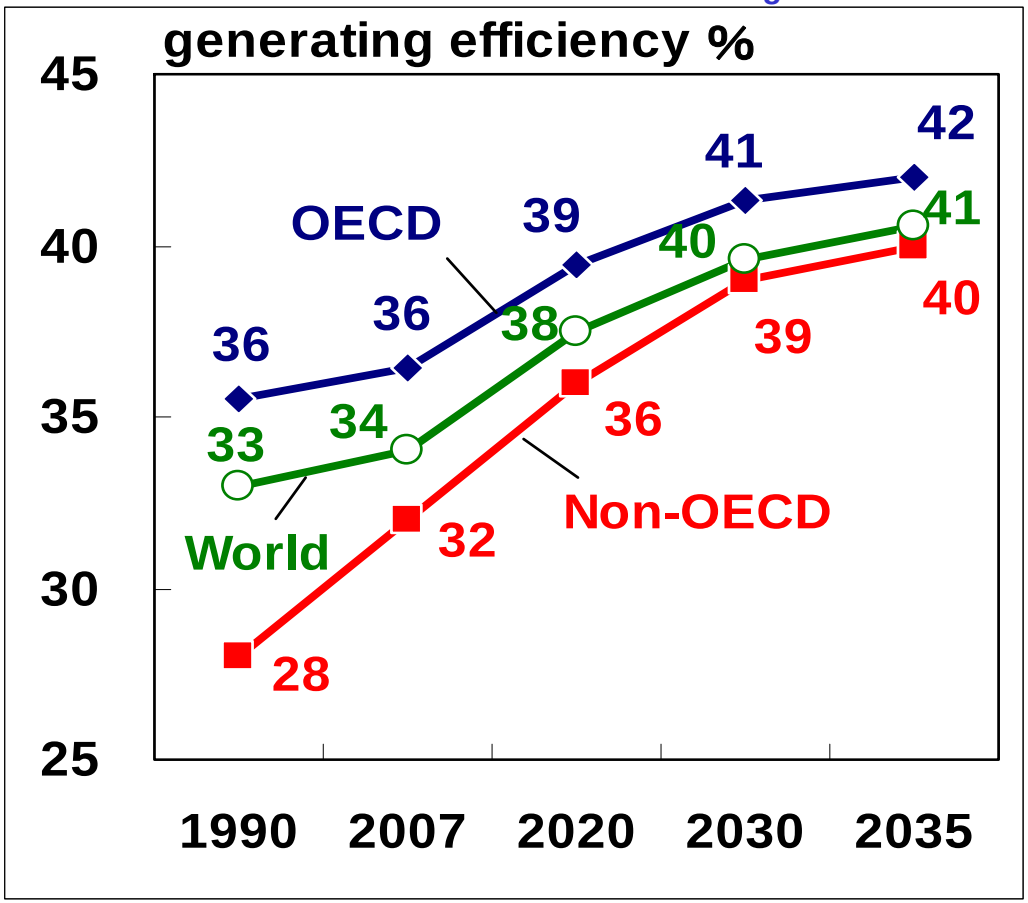
2007
86GW
↓
2035
224GW
(2.7-fold increase)

World nuclear capacity will grow from 392GW in 2007 to 602GW in 2035 (215 GW growth). Asian countries will introduce nuclear energy most actively by assigning the largest investment into nuclear power development (141GW growth).

Efficiency of Coal-Fired Power Plant

Efficiency of Coal Fired Power Plant * (Reference Case)

* Average on stock basis



Reference case : Sub-critical, Super-critical ･･･ 70%,
Ultra Super-critical, IGCC, IGFC･･･30%

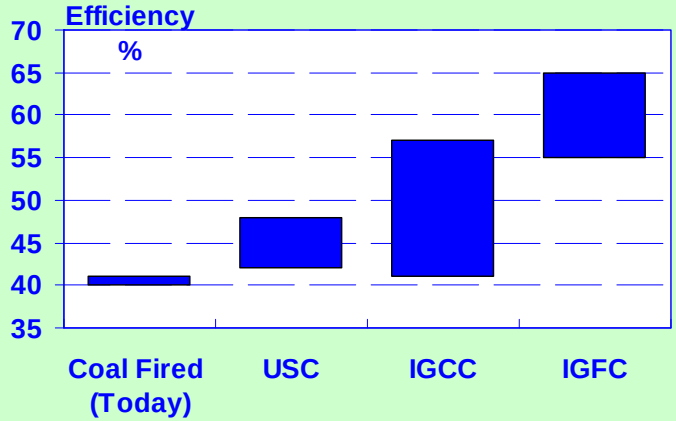
Advanced Technology case : Sub-critical, Super-critical ･･･ 10%,
Ultra Super-critical, IGCC, IGFC･･･90%

Energy Efficiency (World)

2007
34 %
↓
2035

Reference	Advanced
41 % (+7%)	**45 %** (+11%)

High Efficiency Power Plant



Issues

Asian countries are expected to lead the world's energy demand and CO_2 emissions growth.

- ***Industrialization***
- ***Urbanization***
- ***Motorization***
- ***Electrification***

How to ensure energy supply security will continue to be the key policy agenda across the region.

- ***Energy infrastructure development***
- ***Energy diversification***
- ***Energy supply security***

Efforts are necessary to create environment that can support investment to the energy efficient and low-carbon technologies.

Regional cooperation will strengthen energy supply security and sustainable development, which will ultimately lead to mutual prosperity.

Results Summary

In the reference case, world dependence on fossil energy in 2035 is still at the higher level of 86% in comparison with 89% in 2007 and 93% in 1980. Though Asia's dependence of 88% in 2035 is significantly lower than that of 94% in 2007, it is still higher than that of the world. (p11, p12)

World CO2 emissions will increase 1.4 fold from 28.8 billion ton in 2007 to 41.5 billion ton in 2035 in the Reference case. In Post-Kyoto period of 2020, CO2 emissions from OECD countries will increase by 0.3 billion ton. On the other hand, those from Non-OECD countries will increase 4.9 billion ton, which is substantially higher than that of developed countries. This implies urgent necessity of countermeasures for these countries. (p21)

In the Advanced Technology case where developed countries will provide and transfer their advanced technologies to not only within their countries but also to developing countries in order to mitigate GHG emissions worldwide, world CO2 emissions will reach their peak in 2026 and Asia in 2030. (p26, p27)

Even in China, the Advanced Technology case predicts that China's energy consumption will reach at its peak in 2033. CO2 emissions from China will reach its peak in 2030. If CCS technology is successfully introduced, CO2 emissions will reach the peak in 2025. (p28)

The advanced technology case provides enormous reduction of CO2 emissions by 12.3 billion ton in 2035 compared with the Reference Case. OECD countries will reduce by 4.2 billion ton and Non-OECD countries by 8.1 billion tons. About 6.8 billion ton of potential reduction in Asian countries is estimated, which implies necessity of technology transfer especially toward these Asian countries. (p26, p27)

Energy savings, nuclear, renewables, fuel switching to lower carbon content, and CCS technology are the major counter measures toward mitigation of GHG emissions. These contribute 5.7 billion ton (46%), 1.3 billion ton (10%), 1.2 billion ton (10%), and 1.5 billion ton (12%), and 2.6 billion ton (22%) respectively in total reduction of 12.3 billion ton in 2035. (p29)