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Asia / World Energy Outlook 2010

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

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Projection Outline

● **Objective:** Attempt to quantitatively simulate realistic energy pictures of energy demand and supply in a fully logical and consistent way, with investigation into current socio-economic situations and energy fundamentals, in both Asia and the world. Particularly, analysis of Asia is carefully implemented through the exchange of information with numerous research institutes and organizations in the region.

● **Projection Period:**

2008 ~ 2035 (detailed energy supply and demand analysis for each country)

2035 ~ 2050 (rough sketch for Asia and the World)

● **Methodology:** Energy Demand and Supply Model, Macro-Economic Model, Bottom-up Type Technology Estimation Model

● **Scenarios:**

■ **Reference**

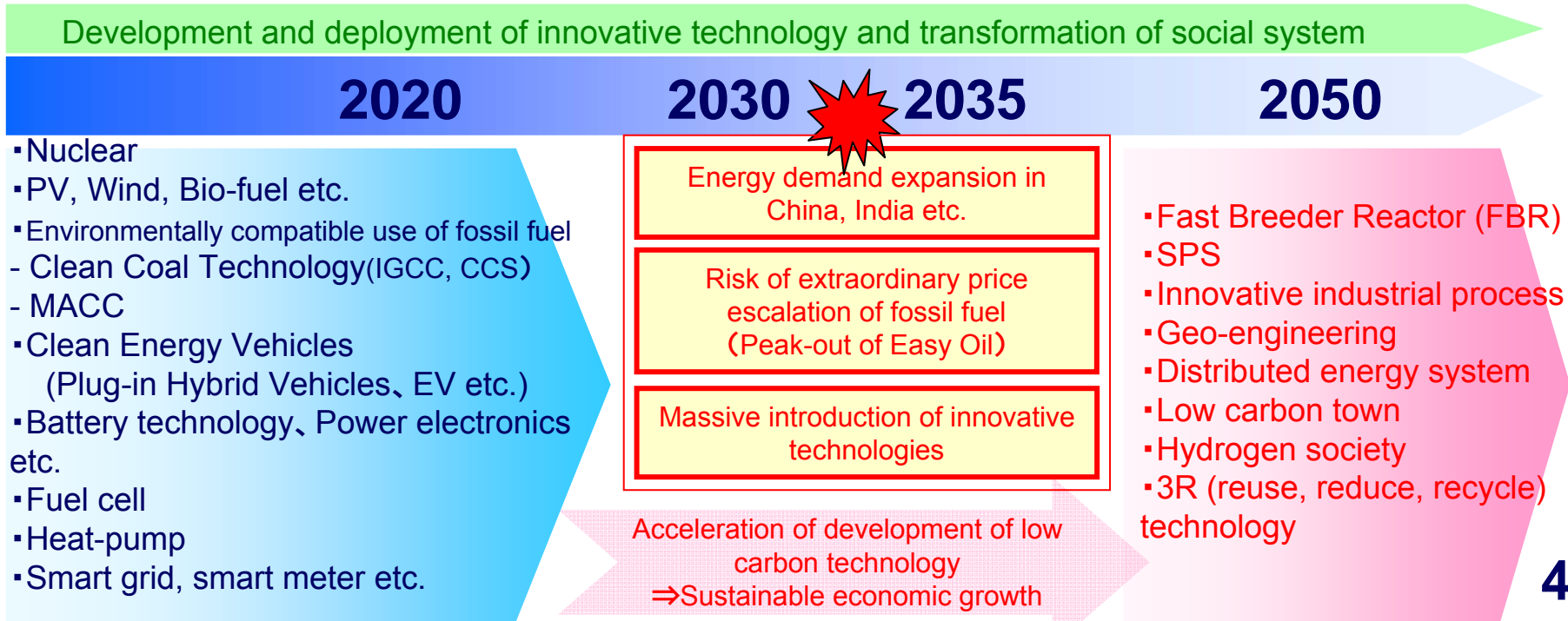
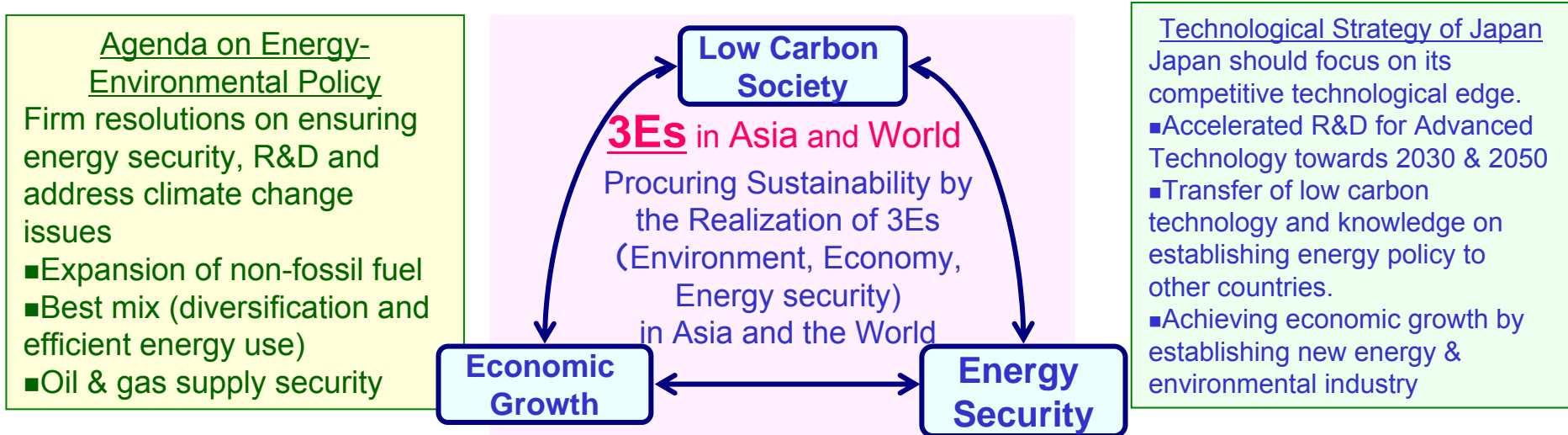
Reference scenario assumes highly probable deployment of energy policy and energy technology based on current economic & political situations, which yields normative future evolution of energy demand and supply

■ **Technologically Advanced Scenario (Tech. Adv.)**

This scenario develops future picture which assumes;

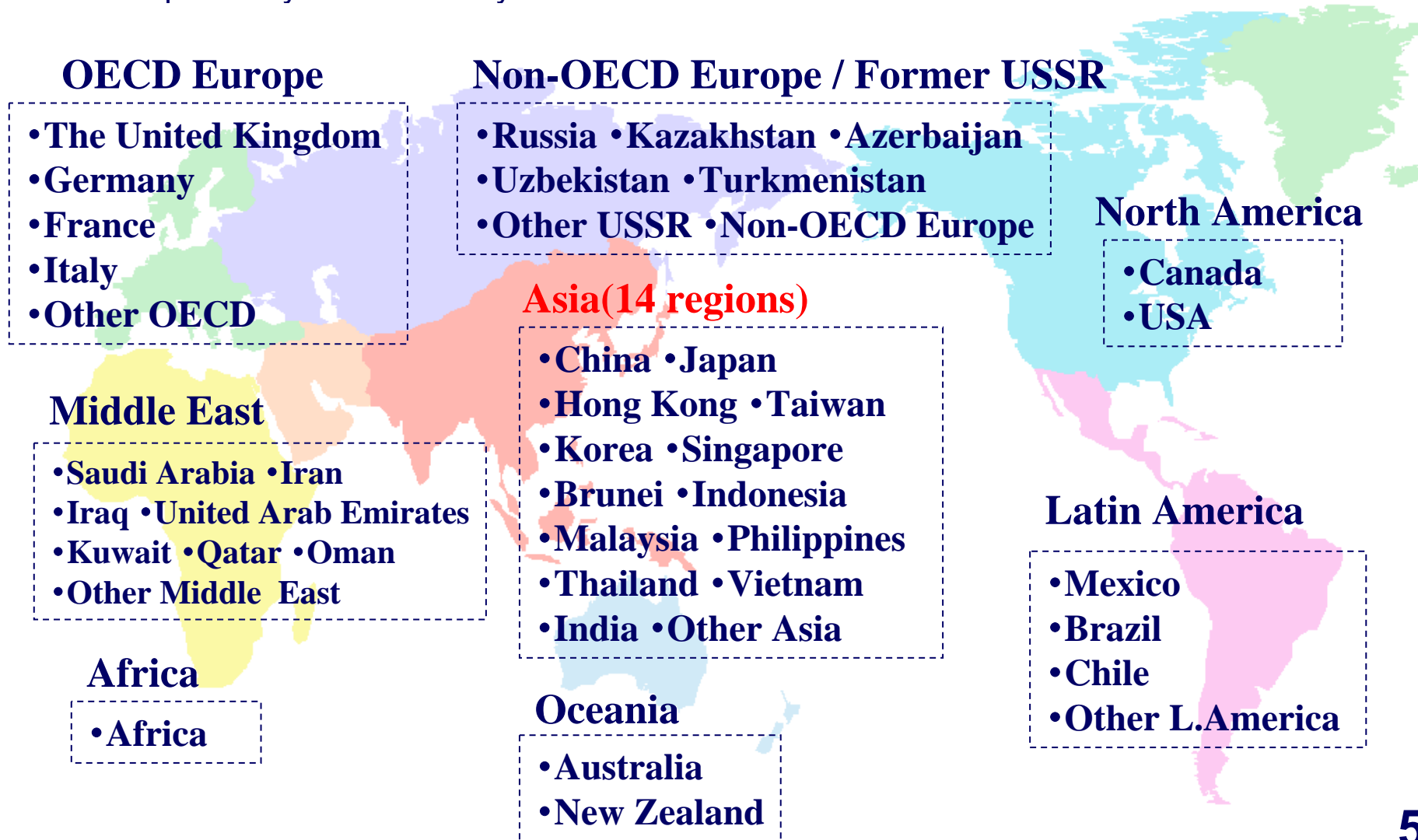
- Accelerated R&D encourages global deployment of advanced technology.
- Global technological cooperation and technology transfer from developed to developing countries are promoted.
- All the countries of the world take technologically advanced measures in order to secure energy demand and supply.

Towards the Realization of 3Es (Environment, Economy, Energy security) in Asia and the World

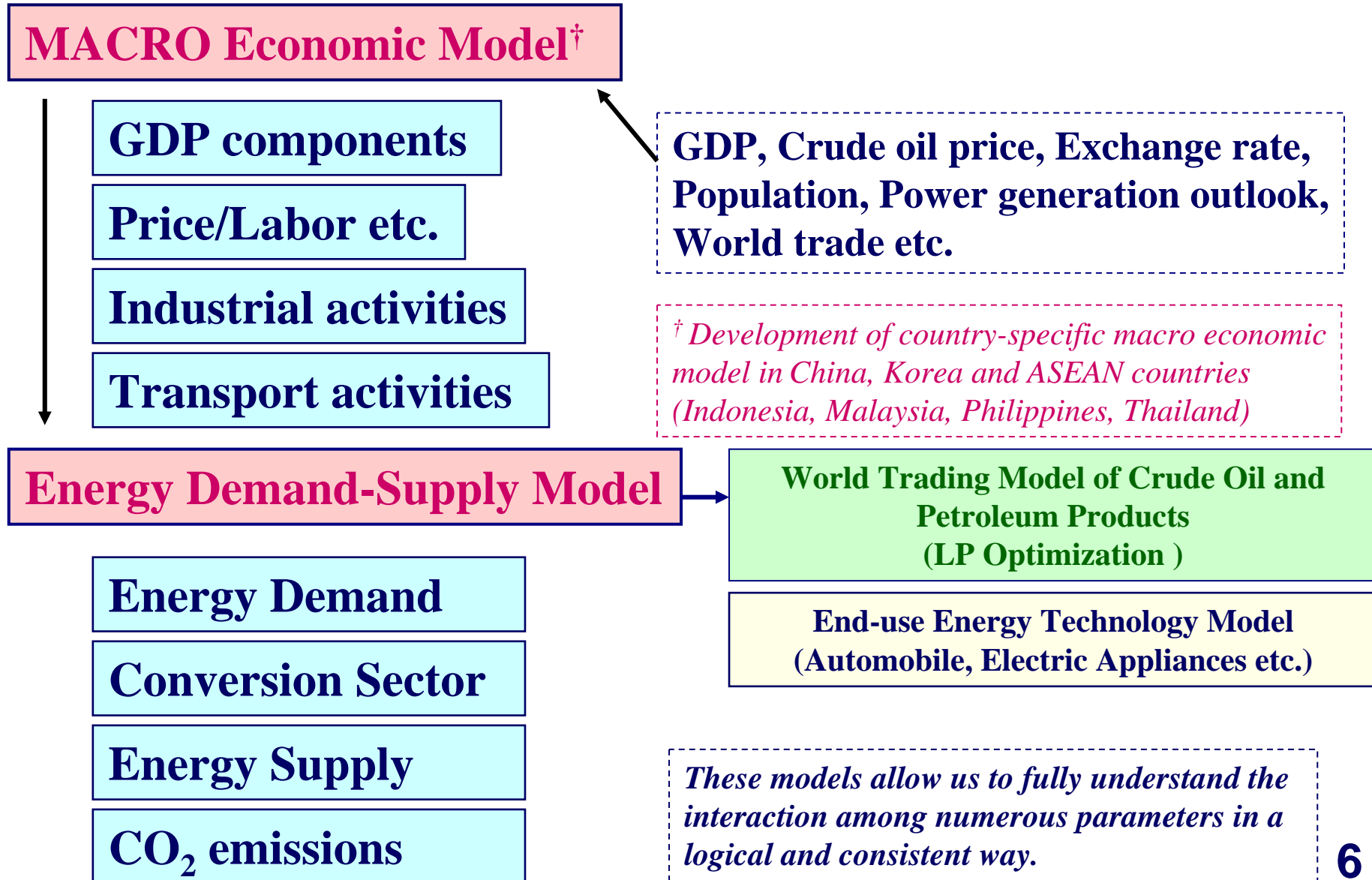


Geographical Coverage

- The whole world is geographically divided into 43 regions, Asia into 14 regions.
- Geopolitically detailed analysis into Asian countries.



Basic Framework



Outline - Asia/World Energy Outlook 2010 -

- **Major Assumptions**

- GDP, Population, and Energy Prices

- **Projection Results up to 2035: World and Asia**

- Primary Energy Demand, and CO₂ Emissions
- Motorization, Power Generation Mix, and Renewables

- **Energy Outlook in China and India**

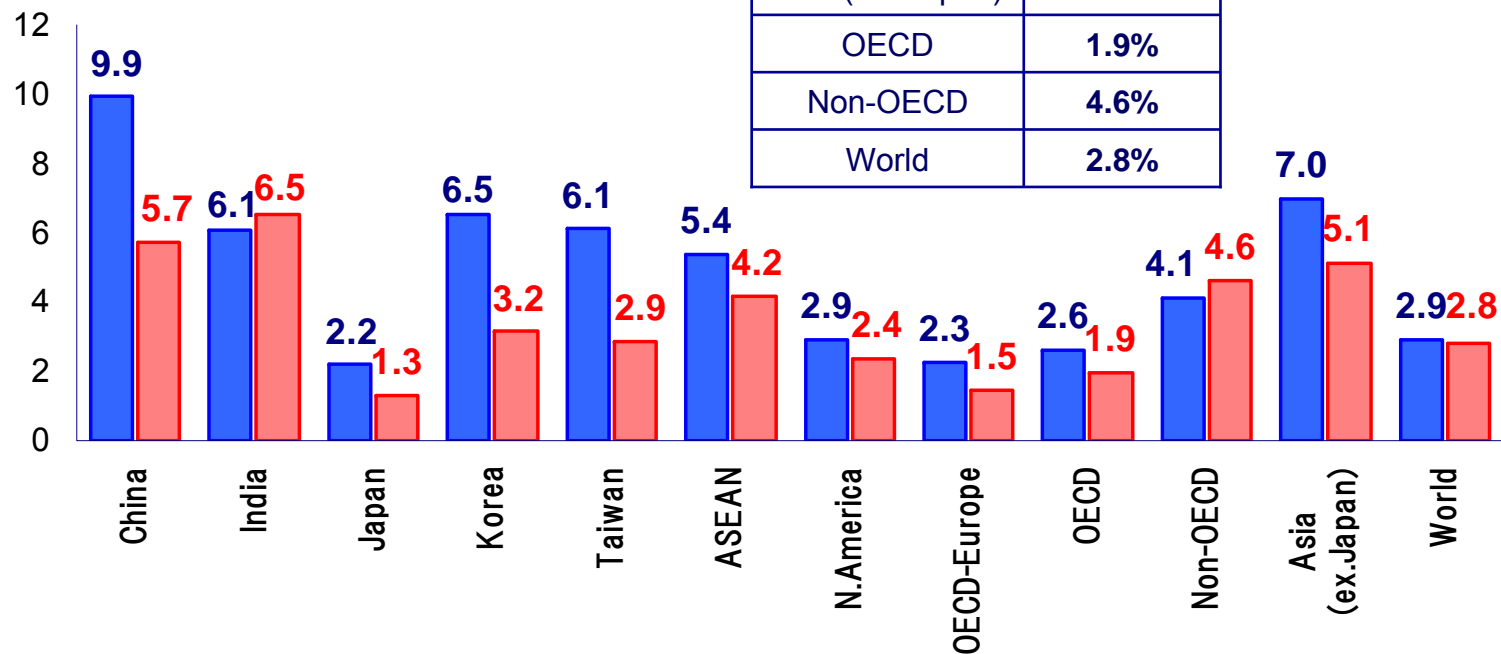
- **Energy Outlook through 2050**

- **Implications**

Major Assumption: GDP

Average Annual Growth Rate (%)

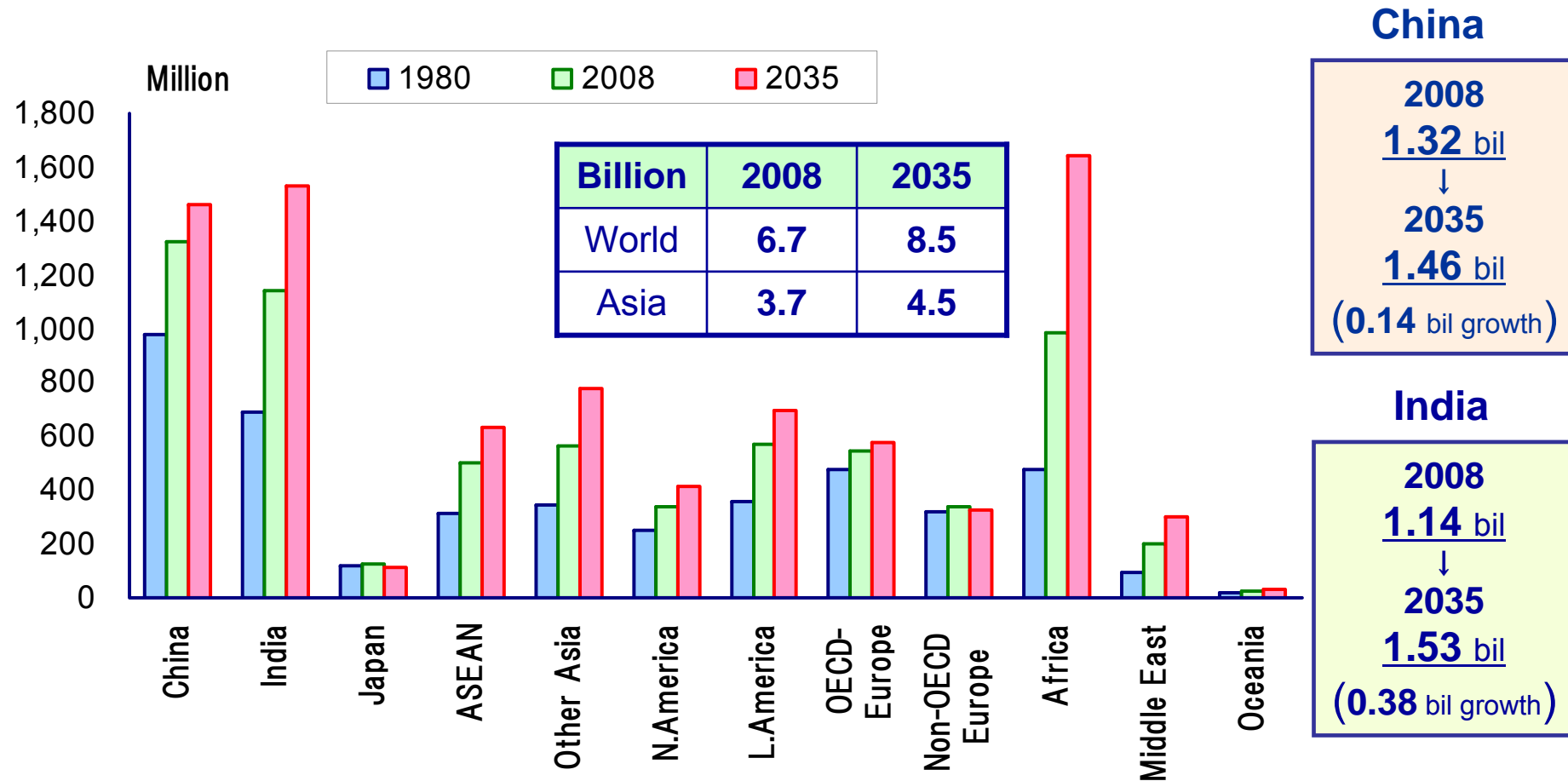
■ 1980-2008 ■ 2008-2035



	2008-2035
China	5.7%
India	6.5%
Asia (ex. Japan)	5.1%
OECD	1.9%
Non-OECD	4.6%
World	2.8%

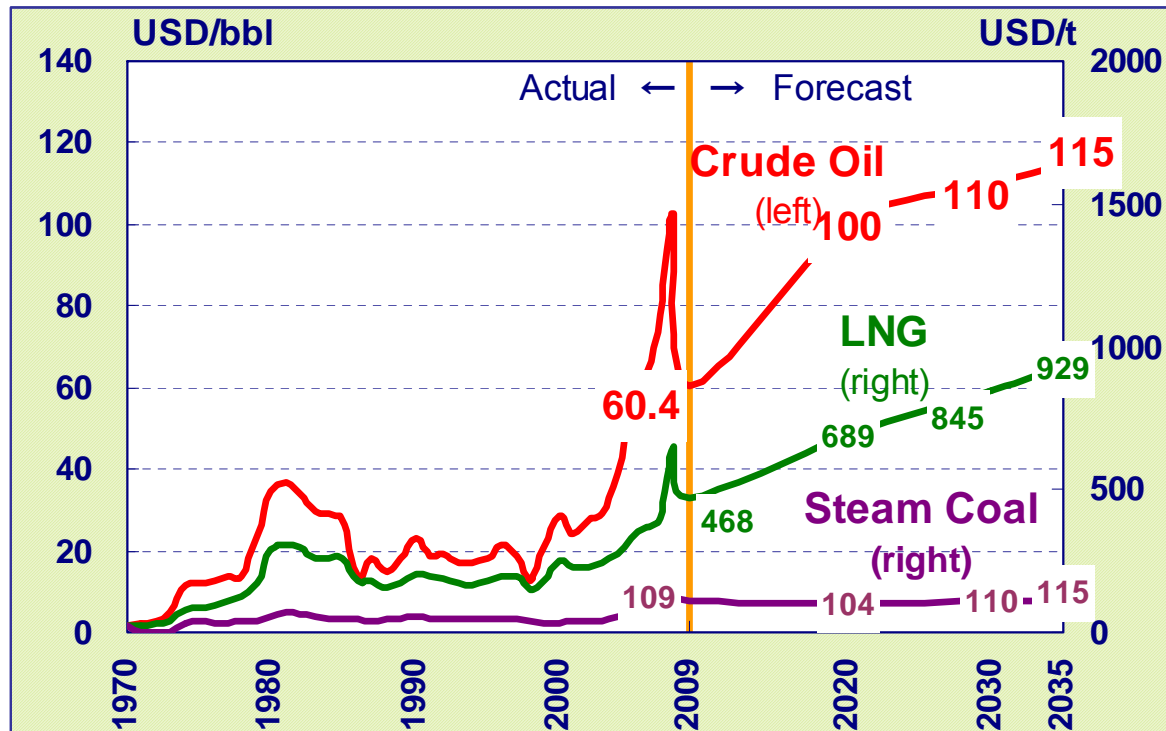
- World economy will continue to grow steadily at 2.8% per annum through 2035. Repercussions from the recent financial crisis were globally felt to slow the economic growth, but with the economic stimulus measures by numerous countries will lead to early recovery.
- GDP in China will continue to achieve an annual growth rate of 5.7% per year shifting from the investment- and export-driven growth to the domestic demand-driven one.
- GDP in India will register a high growth rate at 6.5% per year, reflecting increases in improved labor quality, and liberalization and direct investment from foreign countries.
- ASEAN countries will achieve steady economic growth supported by industrialization and export increases.

Major Assumption: Population



- Of the incremental increase in world population over the period 2008-2035, developing countries account for roughly 90%.
- Population in China and India together will reach about 3 billion and its share will increase to 35% by 2035.
- Chinese population will peak in 2030 as a result of declining birth rate. India's population will represent the biggest in the world by 2035.

Major Assumption: Energy Prices



(*) 2009 real price (**) All the prices are calendar year data; In the graph, energy prices are explained by Japan's import energy price (on a CIF basis).

- Despite a decline in crude oil price from the recorded high level in 2008 to 2009, crude oil price will continue to increase in the future resulting from the tight balance between demand and supply. Oil demand is projected to increase driven mainly by Asia, while upstream investment may not progress at a pace meeting the demand growth (The crude oil price is the median of the assumed price ranges of 90 USD/bbl to 110 USD/bbl in 2020 and 110 USD/bbl to 120 USD/bbl in 2035).
- LNG price is projected to increase in accordance with crude oil price.
- Coal price will show relatively moderate growth compared with the crude oil and LNG.

Energy Prices and Relative Prices

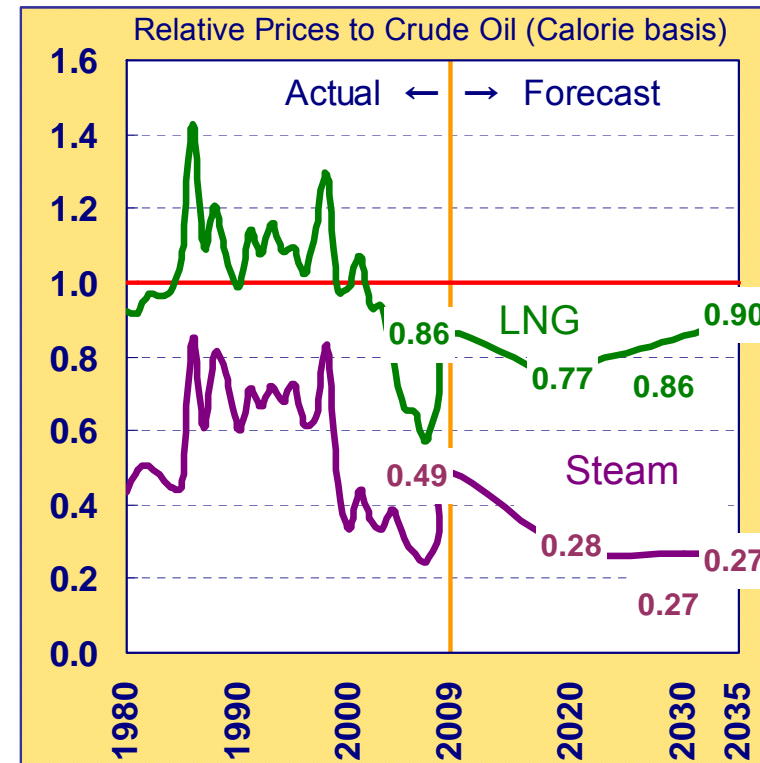
【Real Price & Nominal Price】

		2000	2009	2020	2030	2035
Crude Oil USD/bbl	Real	32	60	100	110	115
	Nominal	28	60	124	167	192
LNG USD/t	Real	282	468	689	845	929
	Nominal	251	468	856	1,280	1,554
Steam Coal USD/t	Real	39	109	104	110	115
	Nominal	35	109	129	167	192

* Real prices are set in 2009.

** Inflation rates are assumed at 2% annually.

【Relative Prices to Crude Oil】



- By 2020, the relative price of natural gas (compared with crude oil price) will become lower from the 2009 level because of the increased supply of unconventional gas. But for the long-term, the price gap between crude oil and LNG will become smaller reflecting on the possible change of LNG price formula and environmental premium of natural gas.
- Coal's relative price will remain roughly constant through 2035.

Assumptions on Technologically Advanced Scenario

Countries in the world are assumed to strengthen the numerous measures that can contribute to ensure energy security and address global warming issues. Additionally, technological development and international transfer of technology will be promoted and advanced technology becomes commercially available internationally as a result.

Regulation, National target, SSL etc.

Carbon Tax, Emissions Trading, RPS, Subsidy Provisions, FIT, Efficiency Standards, Automobile Fuel Efficiency Standard, Low Carbon Fuel Standard, Energy Efficiency Labeling, and National Target.

Promotion of R&D, International Cooperation

Encouragement of Investment for R&D, International Cooperation on Energy Efficient Technology, Support on Establishment of Efficiency Standard

【Demand Side Technology】

■ Industry

Best available technology on industrial processes such as steel making, cement, paper, oil refinery etc. will be deployed internationally.

■ Transport

Clean energy vehicles (highly fuel efficient vehicle, hybrid vehicle, plug-in hybrid vehicle, electric vehicle, fuel cell vehicle) will be globally utilized.

■ Building

Efficient electric appliances (refrigerator, TV etc.), highly efficient water-heating system (heat-pump etc.), efficient air conditioning system, efficient lighting, and strengthening heating insulation

【Supply Side Technology】

■ Renewable

More expansion of Wind, PV, CSP (Concentrated Solar Power), biomass power generation, and bio-fuel

■ Nuclear

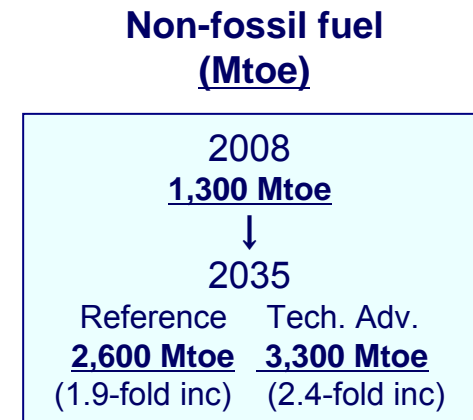
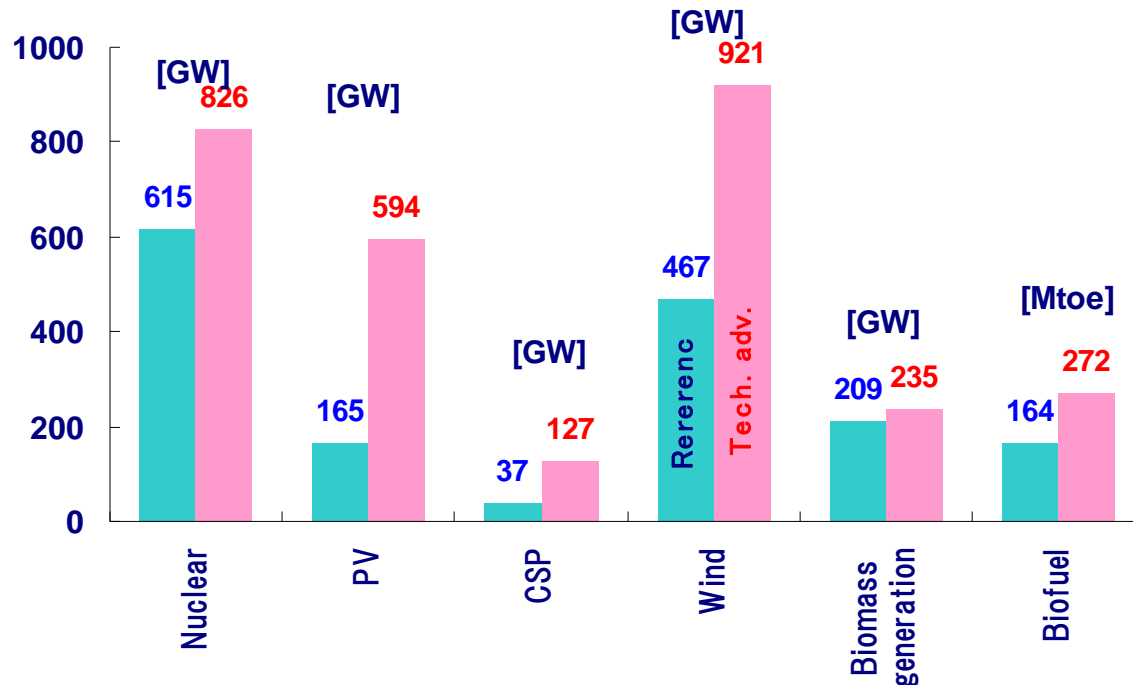
Acceleration of more nuclear power plants, and enhancement of operating ratio

■ High Efficient Fossil-fired Power Plant

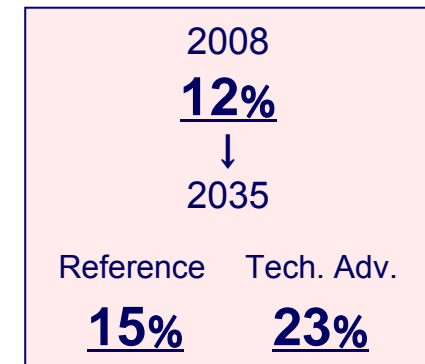
More expansion of coal-fired power plant (USC, IGCC, IGFC), natural gas MACC(More Advanced Combined Cycle)

■ CCS introduction in the power (coal-fired, gas-fired) and industrial sectors

Assumptions on Tech. Adv. Scenario (World, 2035)



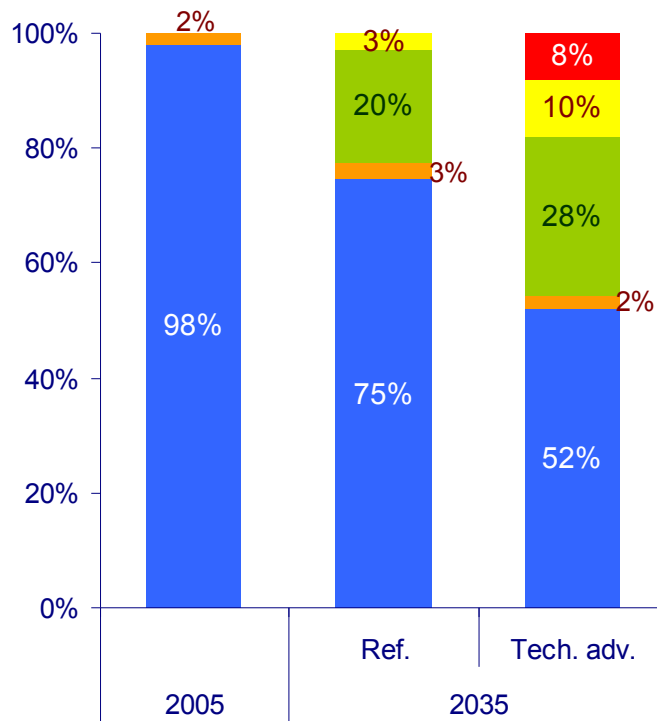
Share of non-fossil fuel



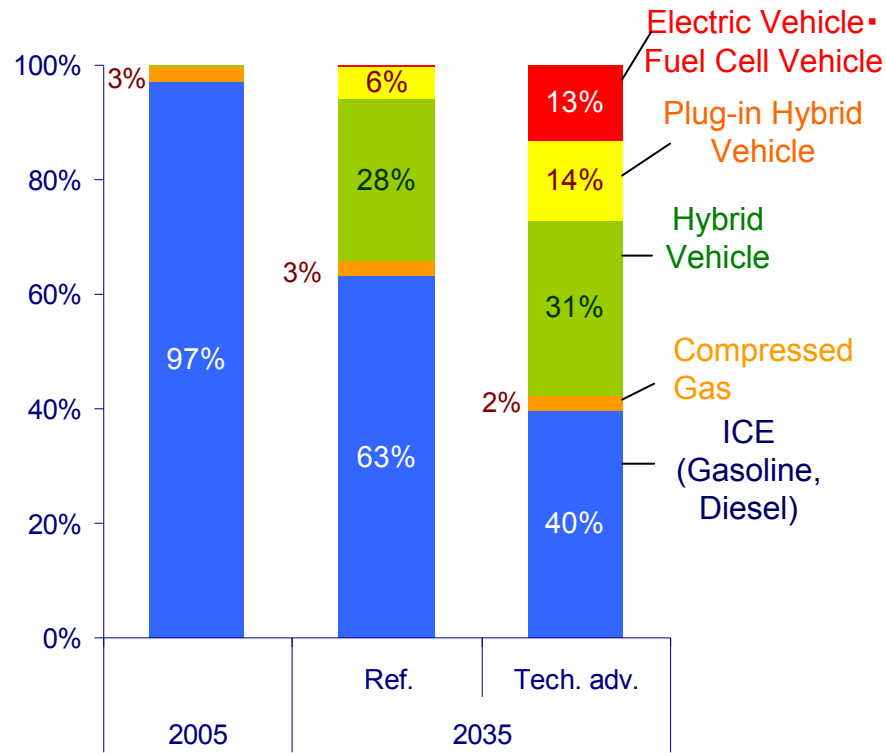
- Further expansion of nuclear and renewables is likely to be realized at the same rate as global electricity demand growth.
- Biofuel will expand substantially assuming cellulosic biofuel, which does not compete with food production and land use, become commercially viable.
- The industry, building and transport sector will respectively achieve 400Mtoe (12% saving), 600 Mtoe (18% saving) and 500 Mtoe (17% saving) of energy saving in 2035 compared with the reference scenario.
- Average efficiency of fossil fuel-fired power generation will reach 47% at 2035 in the Tech. Adv. Scenario compared with that of reference scenario at 42%.

Vehicle Stock and Sales by Type (World)

【The Share of Vehicle Stocks by Type (World)】



【The Share of Vehicles' Annual Sales by Type (World)】



Share of clean energy vehicles in total stocks (2035)

Reference	25 %
Tech. Adv.	48 %

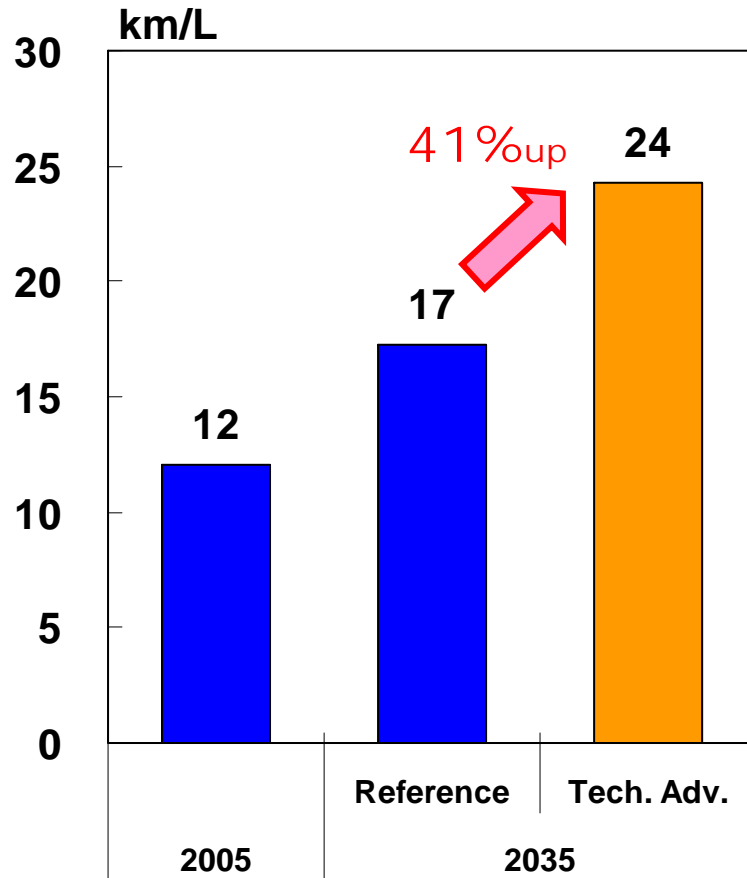
Share of clean energy vehicles in annual sales (2035)

Reference	37 %
Tech. Adv.	60 %

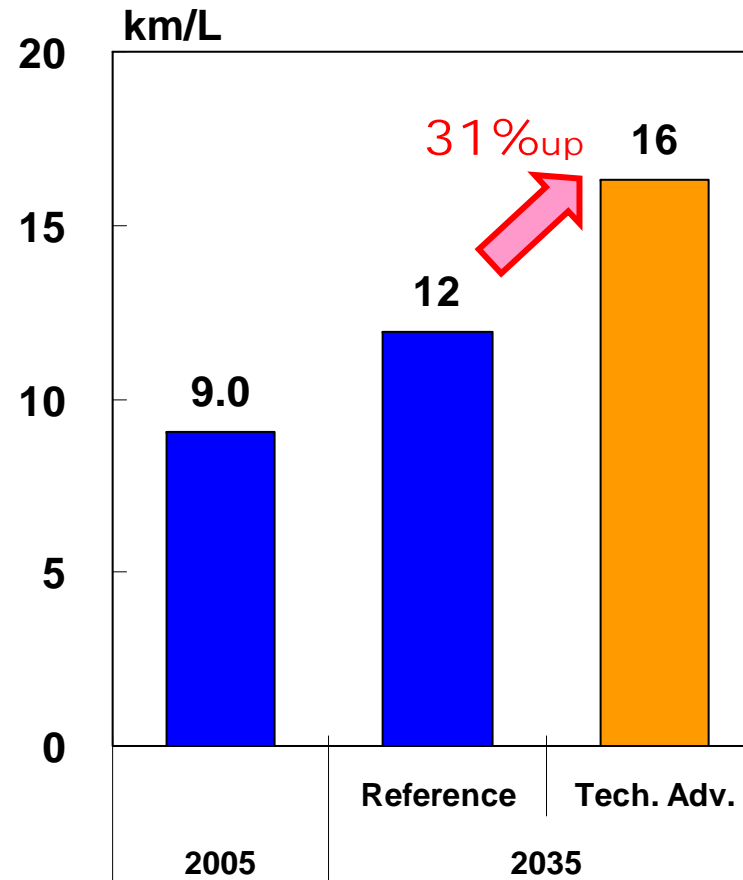
In Tech. Adv. Scenario, the clean energy vehicles will account for approximately 50% of total stocks in 2035.

Fuel Efficiency of Passenger Vehicles (World)

**Fuel Efficiency
(Annual sales basis)**



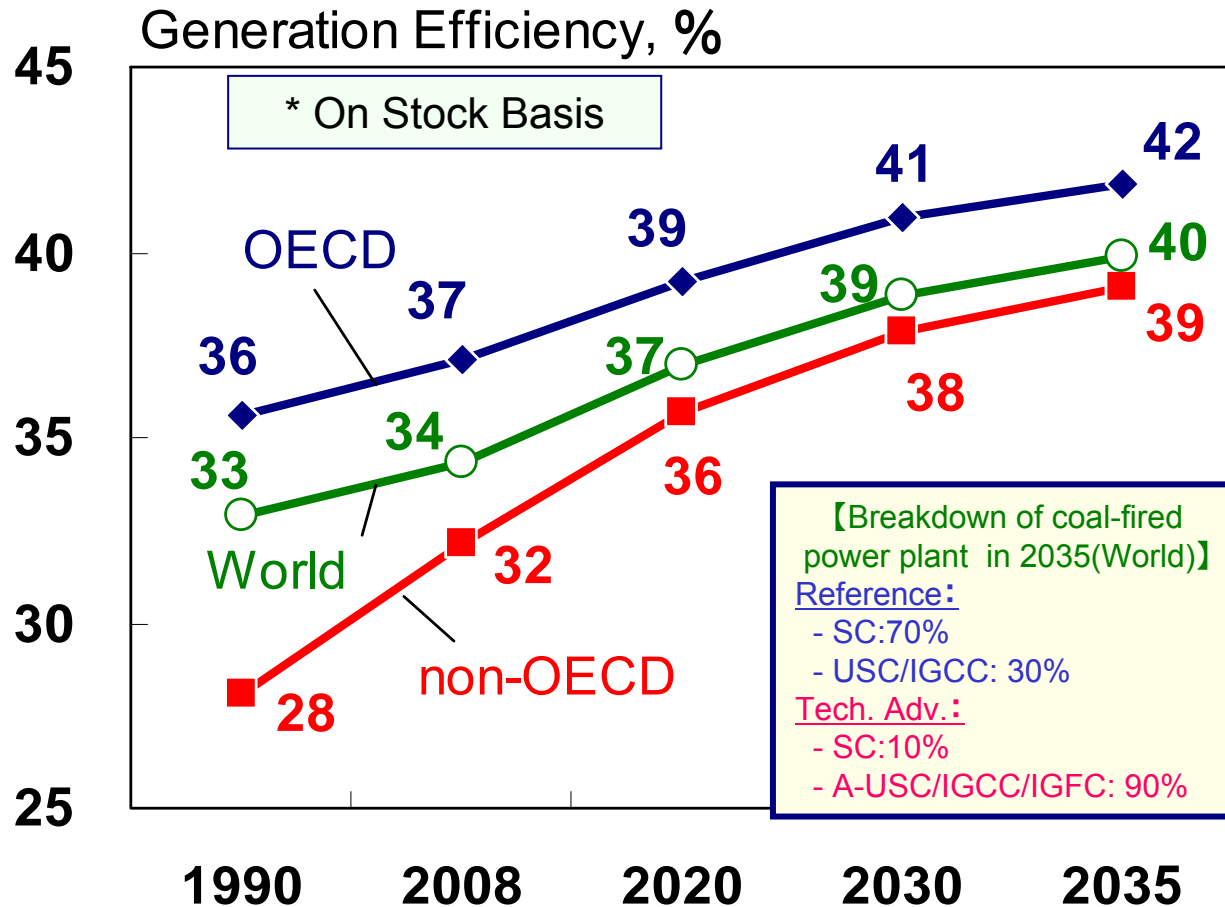
**Fuel Efficiency
(Stock basis)**



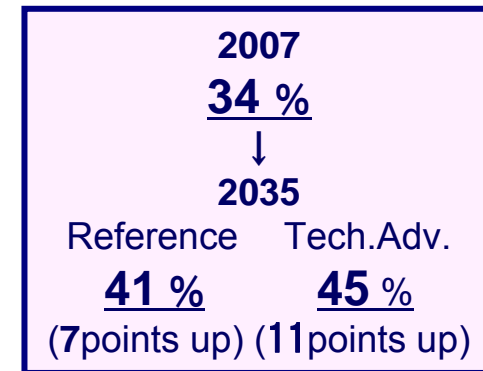
In 2035, the passenger vehicles' fuel efficiency for the Tech. Adv. Scenario will achieve a 31% improvement in comparison with the Reference Scenario.

Power Generation Efficiency of Coal-fired Power Plant

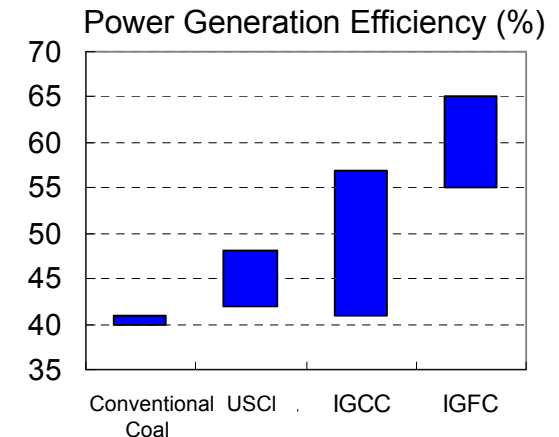
Power Generation Efficiency of Coal-fired Power Plant *(Reference)



Stock-based Efficiency of Coal-fired Power Plant (World)

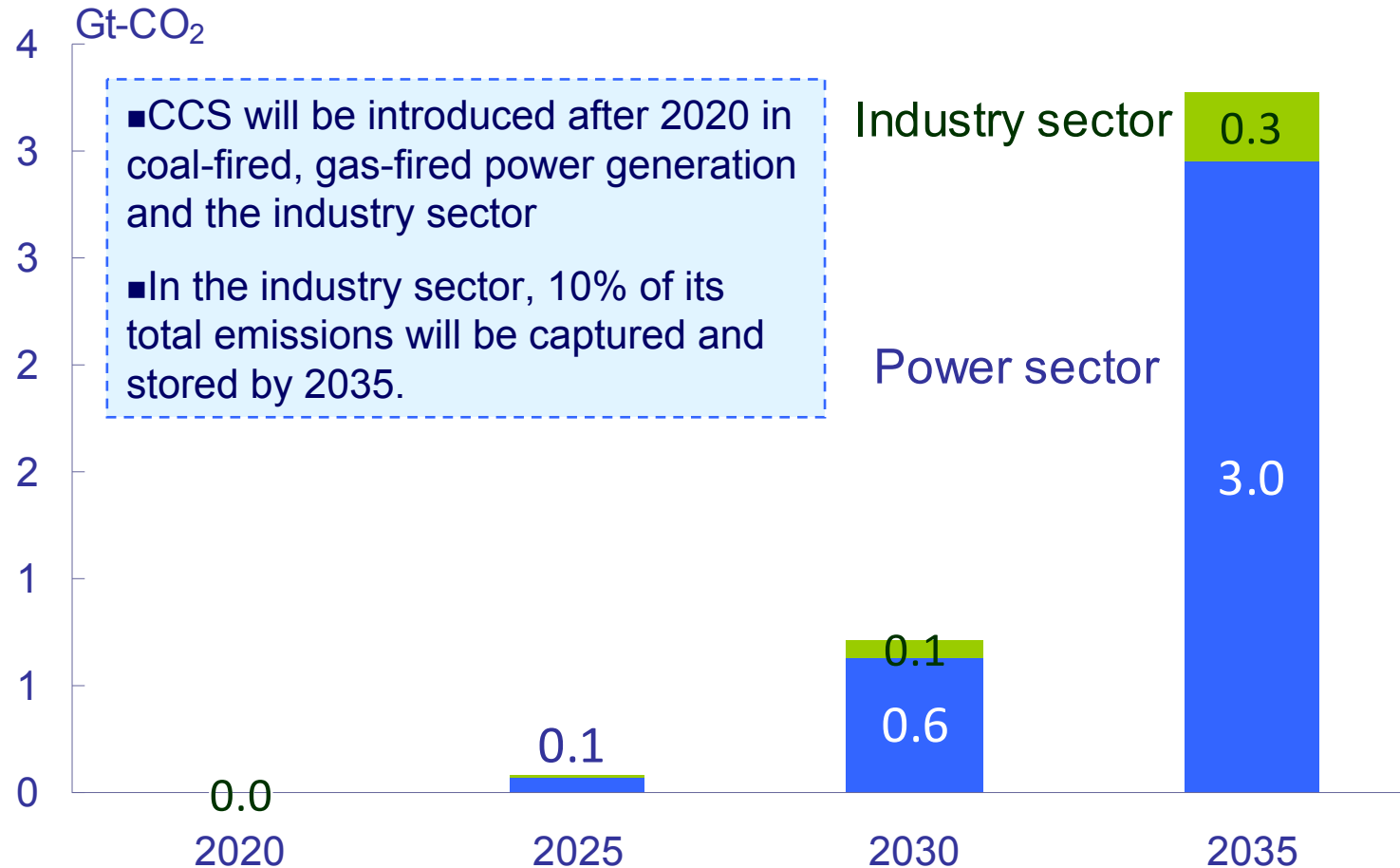


Advanced Coal-fired Plant



In the Tech. Adv. Scenario, additional 1.0 Gt-CO₂ will be reduced due to the enhancement of power generation efficiency compared with Reference Scenario.

CO₂ Capture & Storage (CCS)

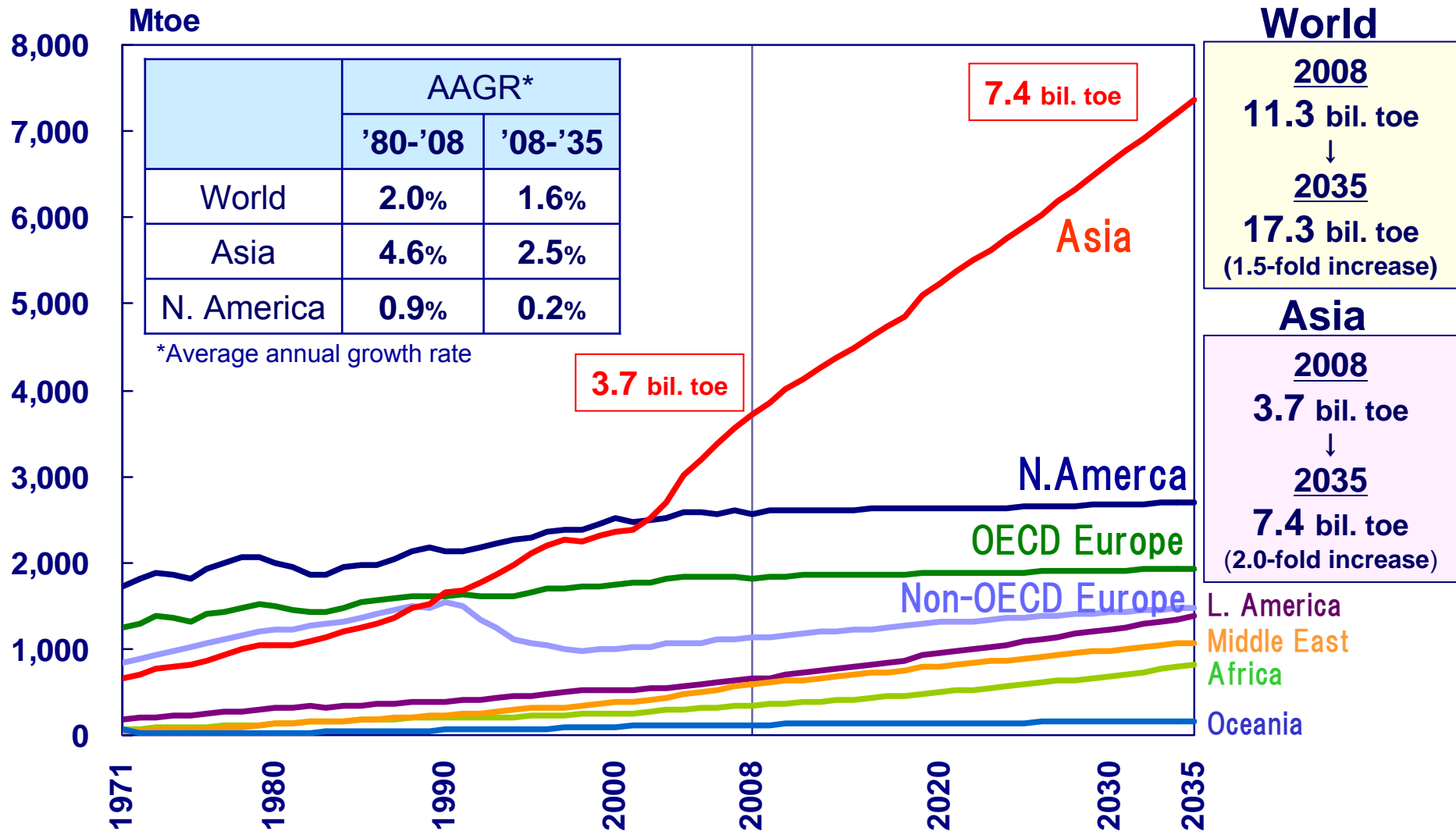


- Cumulative captured and stored CO₂ from 2020 to 2035 will reach 12 Gt. Theoretical potential of CCS in geological structures is estimated at 10 trillion tons, and that of combined total of depleted gas field, oil field and coal field, is estimated to reach 1 trillion ton, suggesting that projected CO₂ emissions reduction from the CCS in the Tech. Adv. Scenario can be accommodated.

Energy Outlook in Asia and the World 2008-2035

Primary Energy Demand by Region (World)

Reference



■ By 2035, primary energy demand of Asia will double from the current level, reflecting high economic growth; 3.7 billion toe(2008) → 7.4 billion toe(2035).

■ Non-OECD will represent 90% of incremental growth of global energy demand toward 2035.

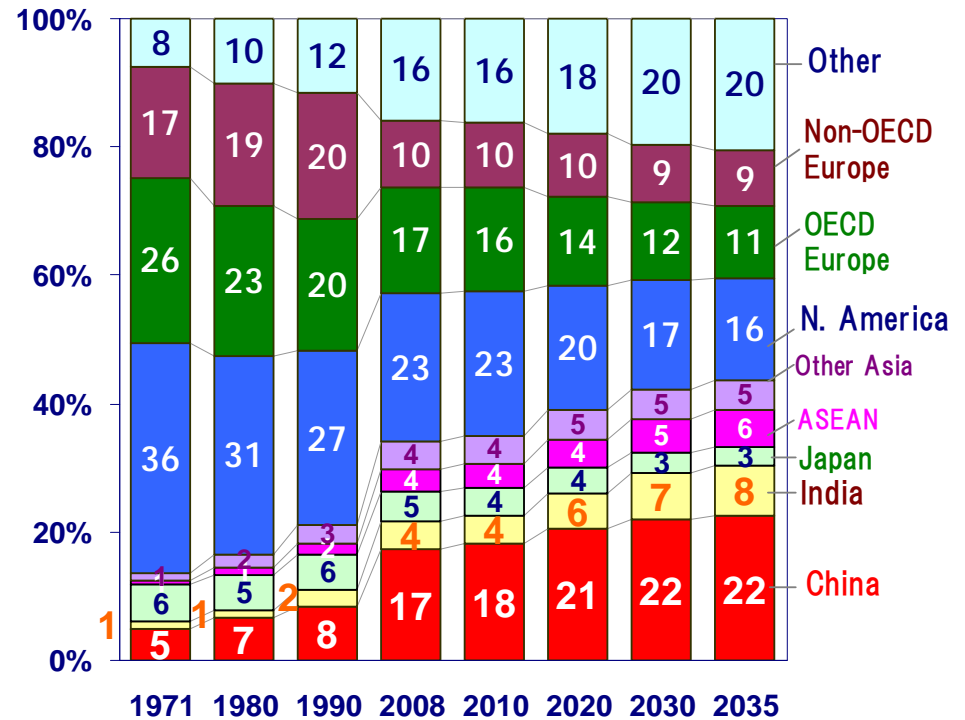
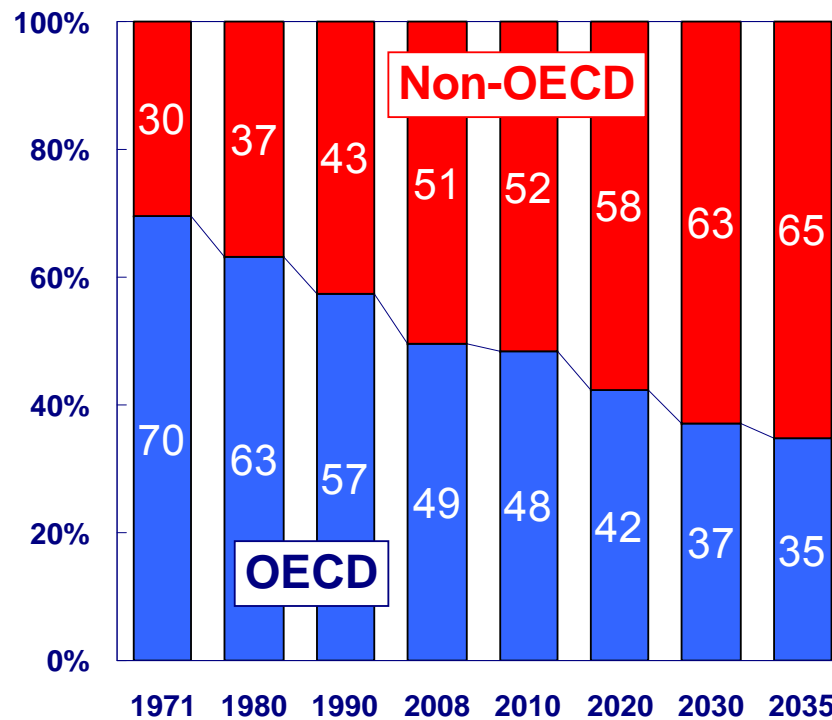
Primary Energy Demand (Regional Share)

Reference

Share in increase (2008-2035)

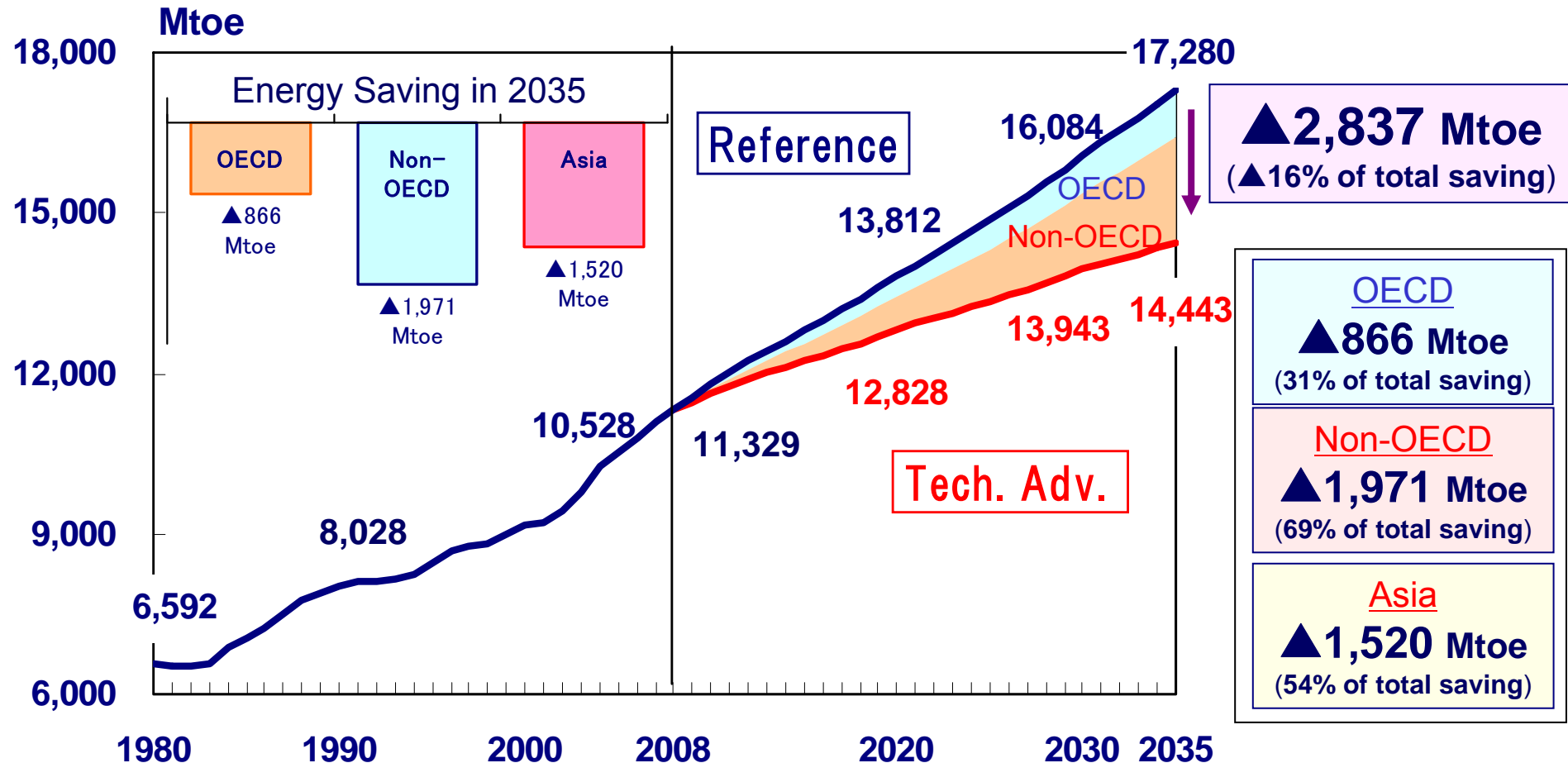
China	India	Japan	ASEAN	Other Asia	N. America	OECD Europe
31%	15%	0%	10%	5%	2%	2%

Asia occupies more than 60% of total growth.



- Reflecting steady economic growth, energy demand in Non-OECD will exceed that of OECD.
- Energy demand in Asia will exhibit a rapid growth, with the share of Asia in the world energy demand expanding to 43% by 2035 from 34% in 2008.
- The share of China in the world energy demand will increase to 22% by 2035, and India to 8%. These two countries will account for around for 30% of world energy demand. The share of Japan will decline from 5% in 2008 to 3% in 2035.

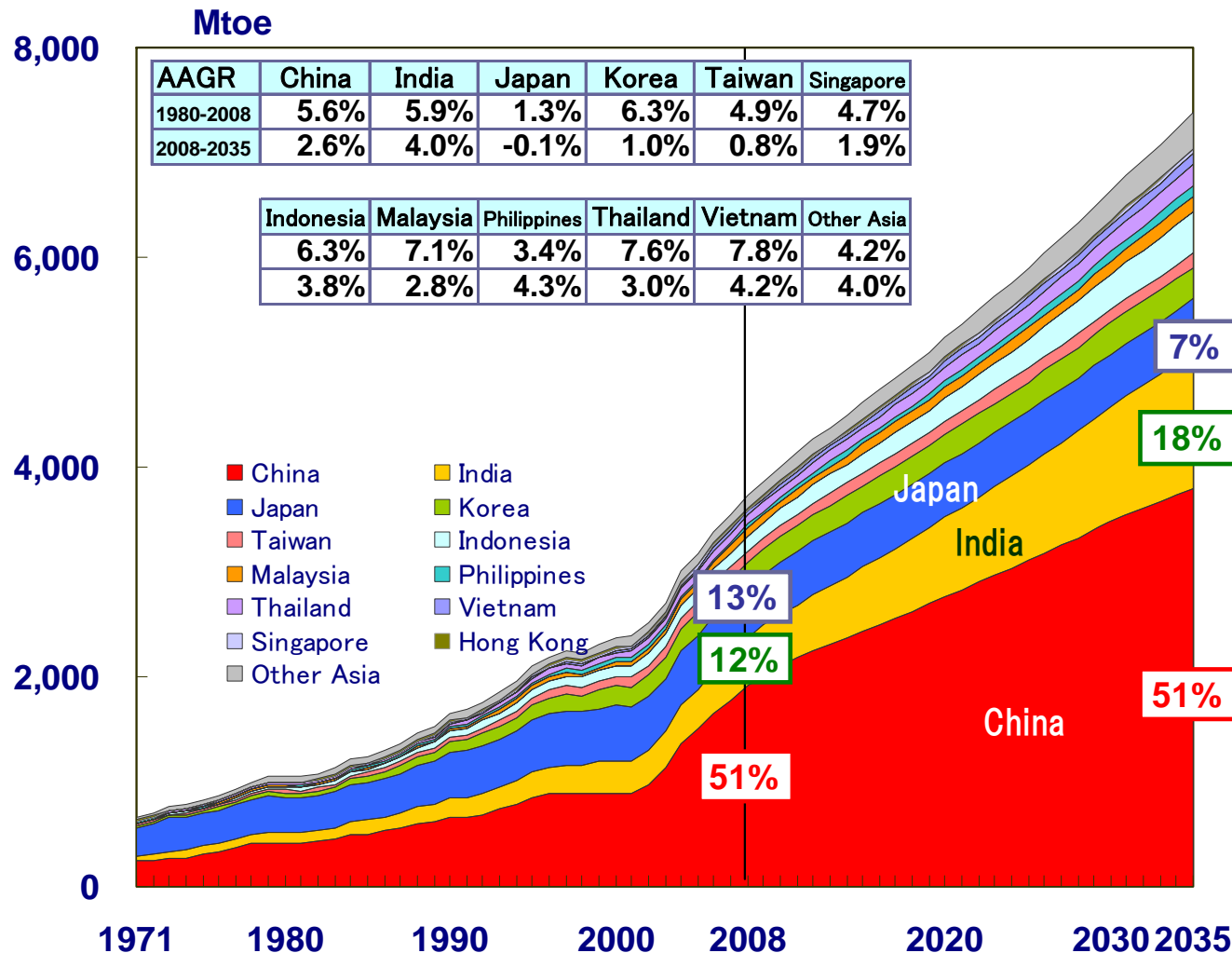
Primary Energy Demand (World)



- In 2035, world total primary energy demand in the Tech. Adv. Scenario will be 2,837 Mtoe (about 16%) lower than the Reference Scenario, and this saving (at 2,837 Mtoe) is approximately 6 times as much as TPED of Japan in 2008.
- TPED saving of Non-OECD in 2035 is more than double that of OECD. The saving potential in Asia is particularly significant.

Primary Energy Demand (Asia)

Reference



Asia

2008
3.7 bil. toe

↓

2035
7.4 bil. toe
(2.0-fold increase)

China / India

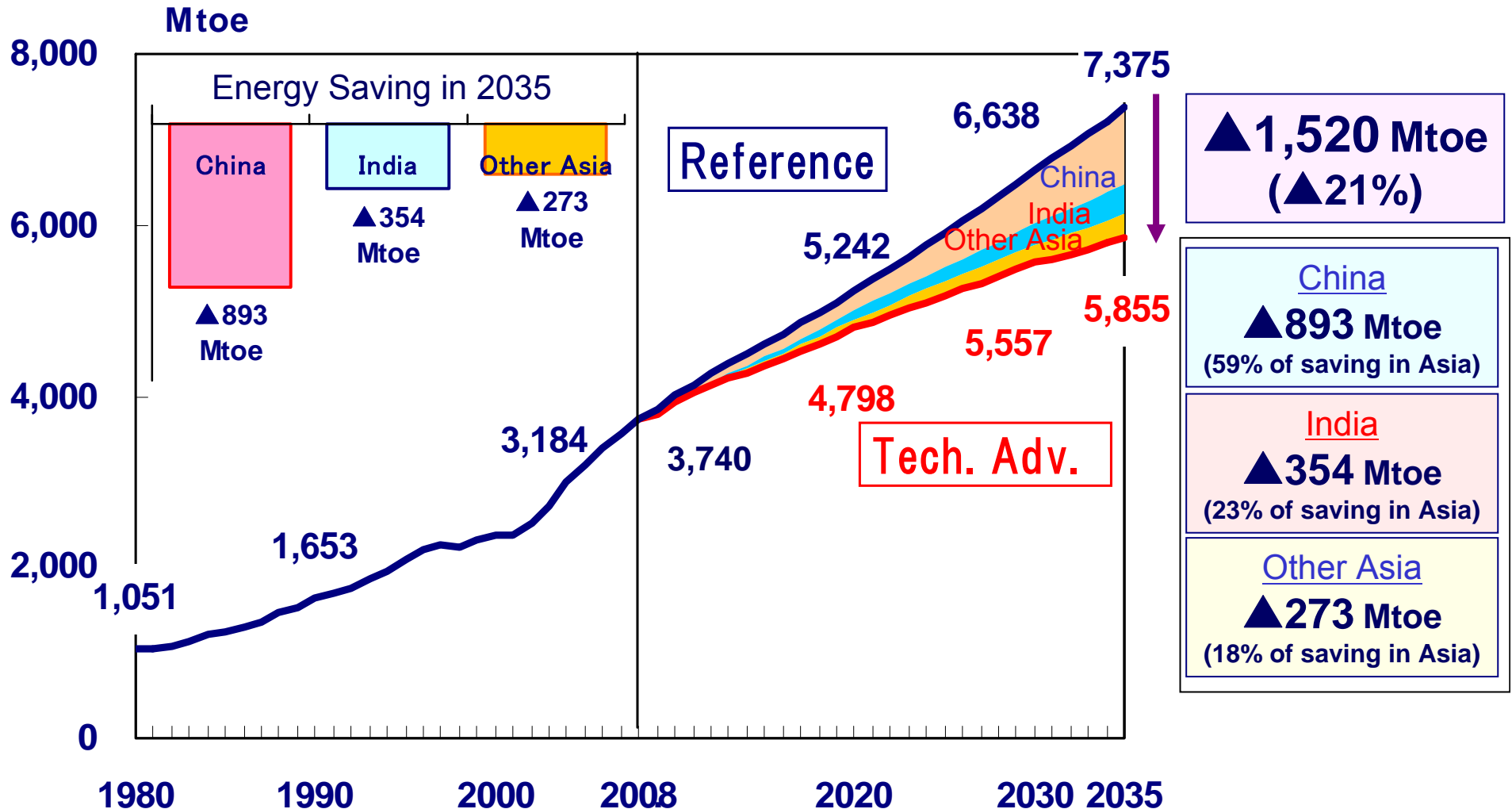
2008
1.9 bil. toe / 0.46 bil. toe

↓

2035
3.8 bil. toe / 1.3 bil. Toe
(2.0-fold inc. / 2.9-fold inc.)

- At the back of steady economic growth, the share of China and India together in Asian primary energy demand will significantly increase to 69% by 2035.
- Japan's energy share in Asia will decline from 13% in 2008 to 7% in 2035 resulting from slow growth in energy demand.

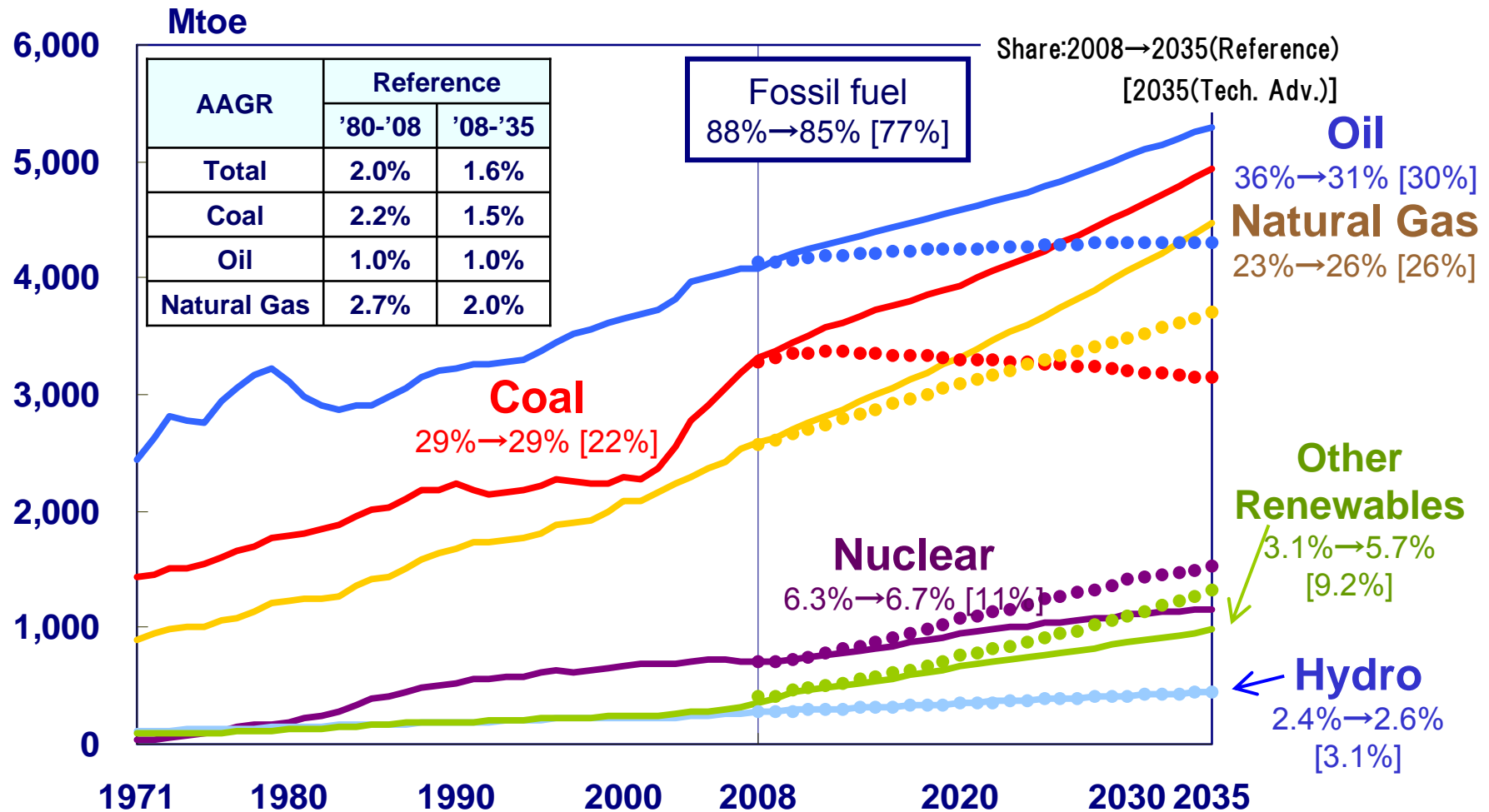
Primary Energy Demand (Asia)



■ In 2035, TPED of Asia in the Tech. Adv. Scenario will be 1,520 Mtoe lower than the Reference Scenario. This saving (at 1,520 Mtoe) is approximately three times as much as TPED of Japan in 2008. China and India will have 82% of the saving potential.

Primary Energy Demand by Type (World)

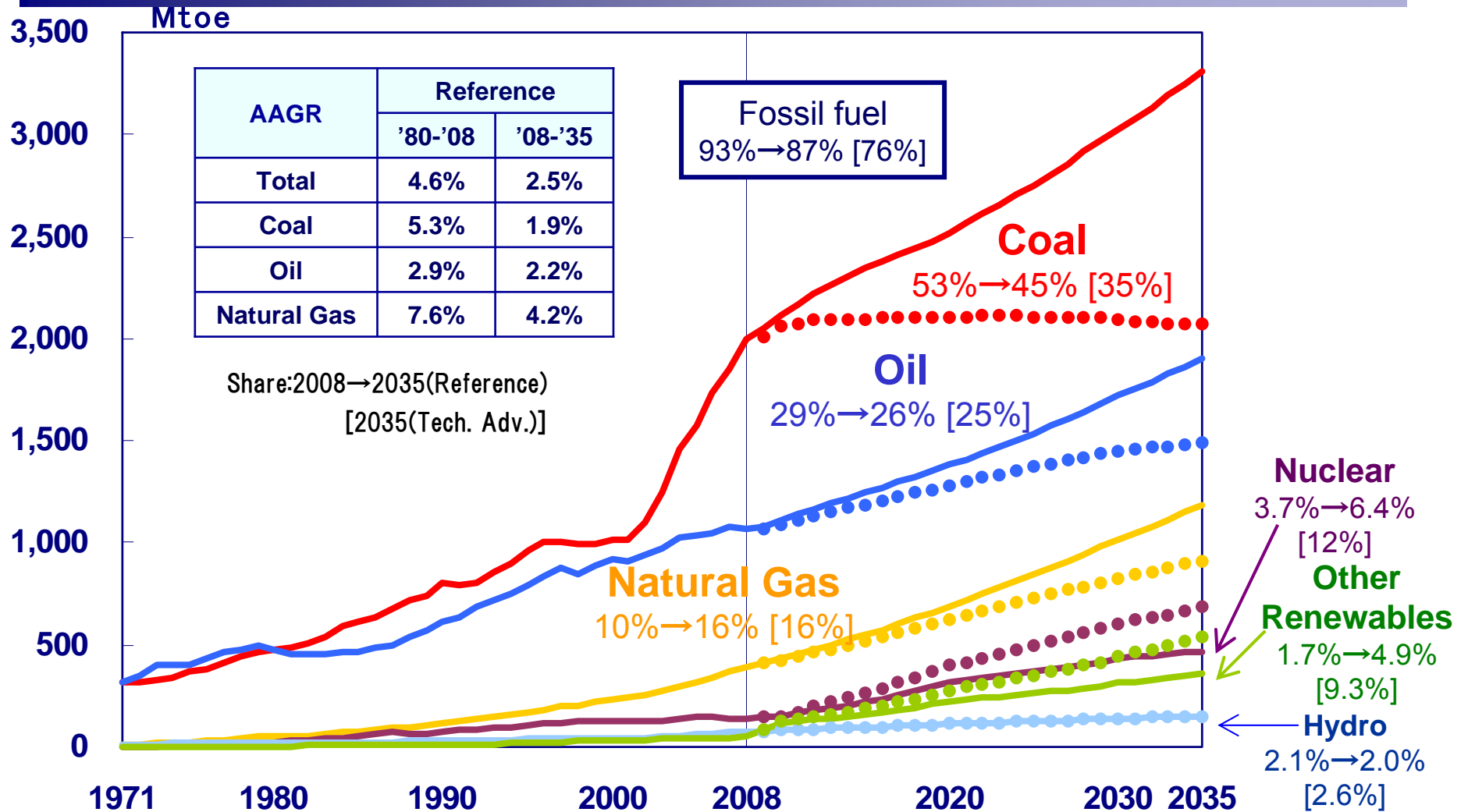
Solid line: Reference
Dotted line: Tech. Adv.



- Oil in both of the Tech. Adv. and Reference Scenarios will maintain the biggest share in primary energy mix by 2035. In the Tech. Adv. Scenario, oil demand will peak in 2030.
- Fossil fuels will continue to account for the largest share by 2035, though its share will slightly decrease from 88% in 2008 to 85% in the Reference Scenario in 2035 or to 77% in the Tech. Adv. scenario
- Natural gas in the Tech. Adv. scenario will continue to grow with its future extensive use in various sectors.

Primary Energy Demand by Type (Asia)

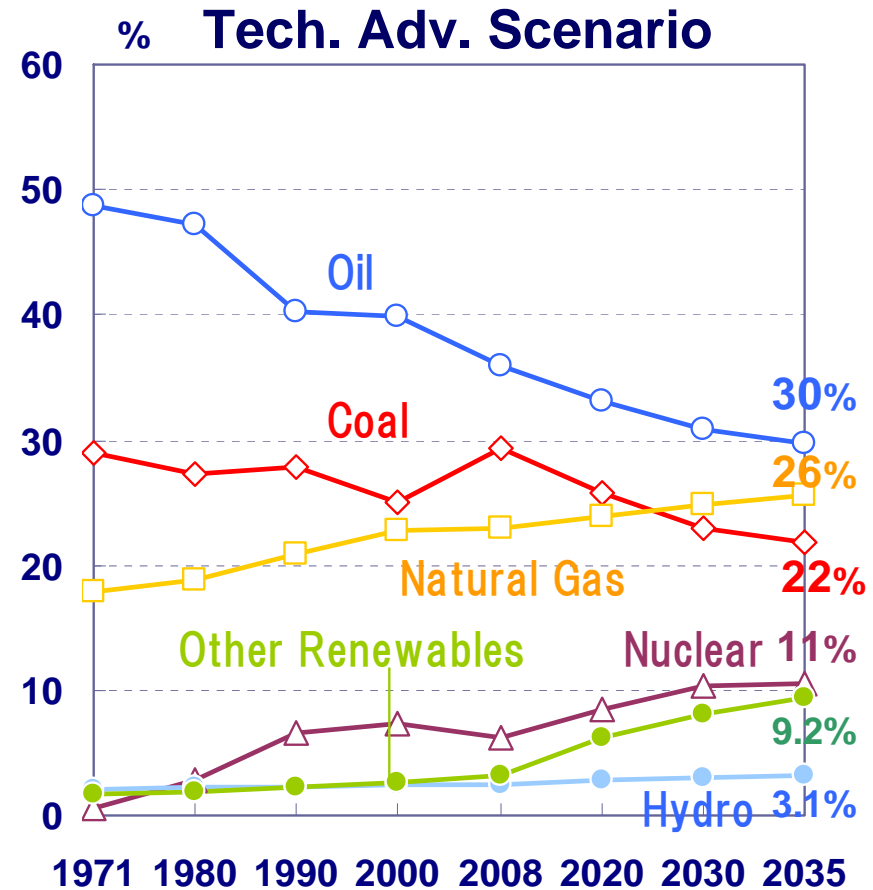
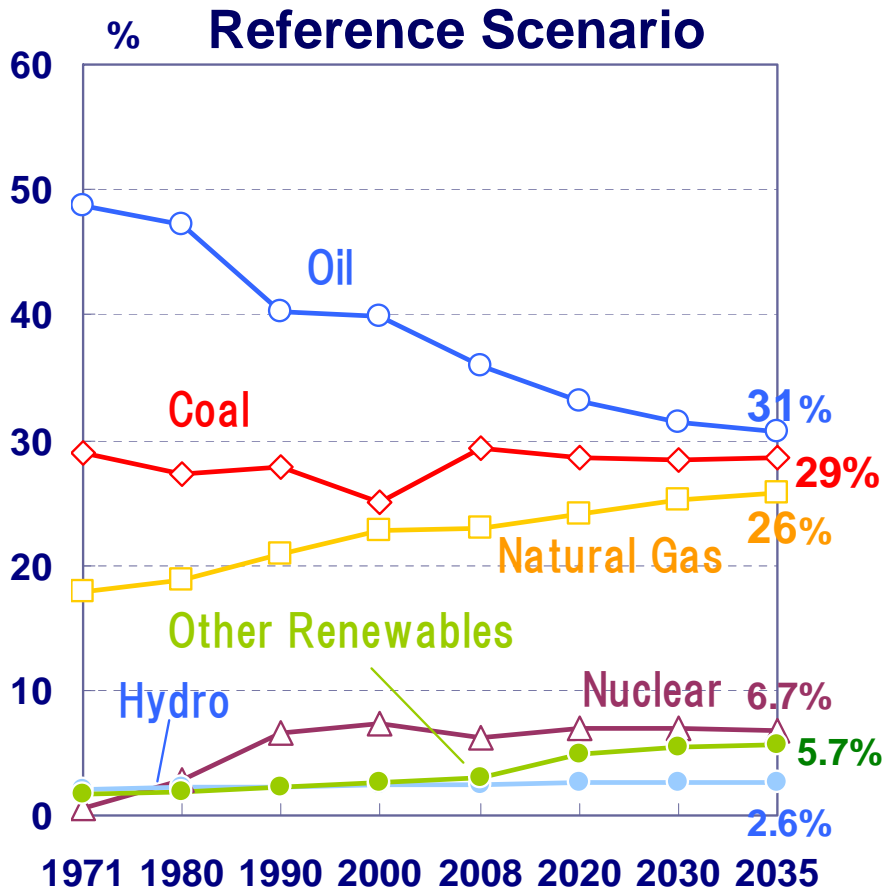
Solid line: Reference
Dotted line: Tech. Adv.



■ Coal and oil will continue to maintain the dominant share in Asian energy demand through 2035. The share of natural gas will increase substantially reaching 16% by 2035, driven mainly by power generation.

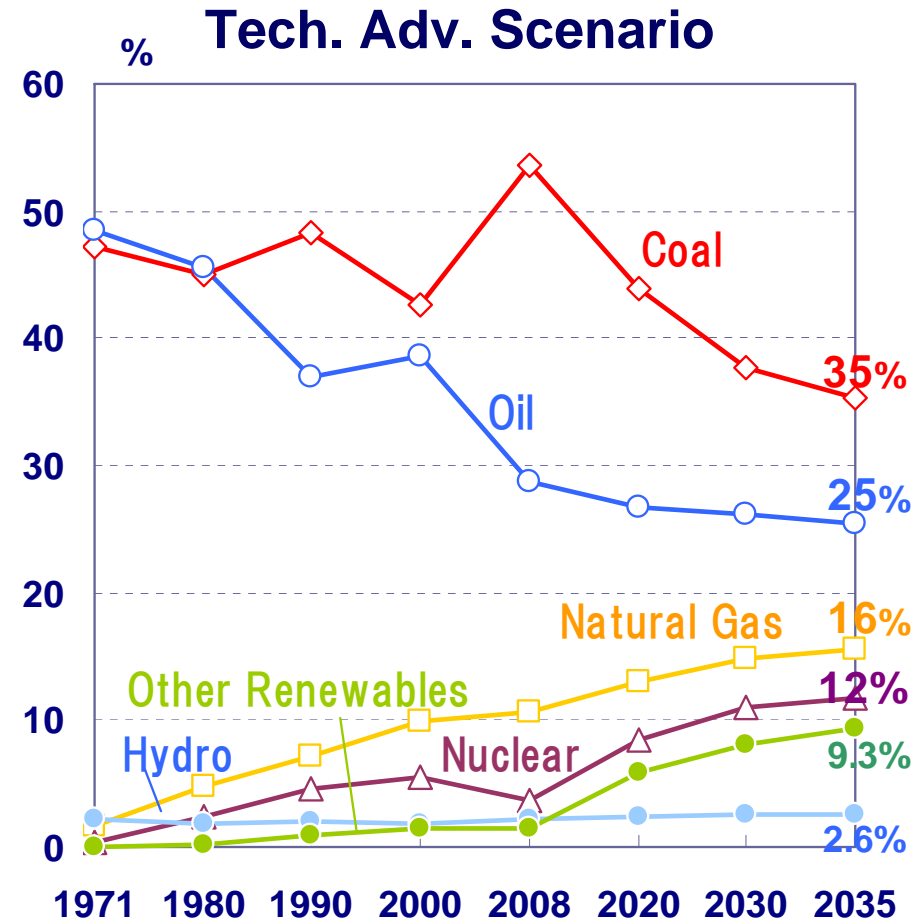
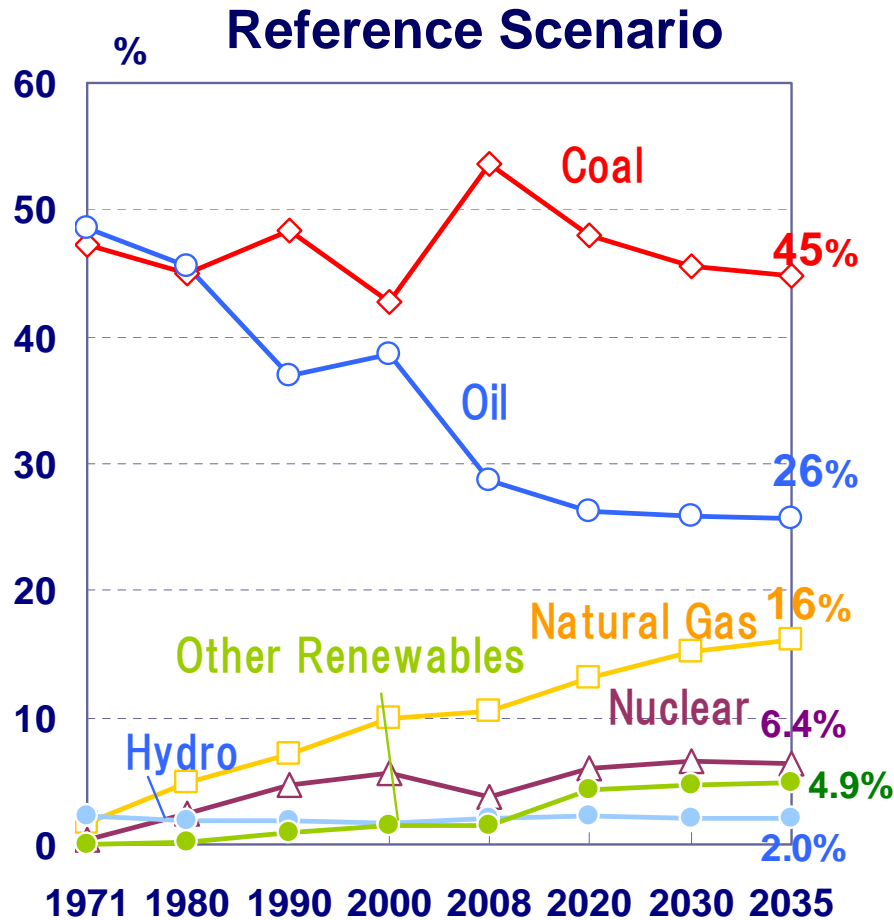
■ Coal share in the Tech. Adv. Scenario will significantly decrease, but will maintain the largest share (35% of total) in primary energy mix by 2035.

Primary Energy Mix (World)



- In the Reference Scenario, the oil's share will significantly decrease, while the share of natural gas and renewables will expand substantially.
- In the Tech. Adv. Scenario, coal will significantly decrease mainly in Non-OECD. The share of nuclear and renewables will gradually expand. Fossil fuel will remain the most important fuel in primary energy mix in 2035, maintaining the 76% share.

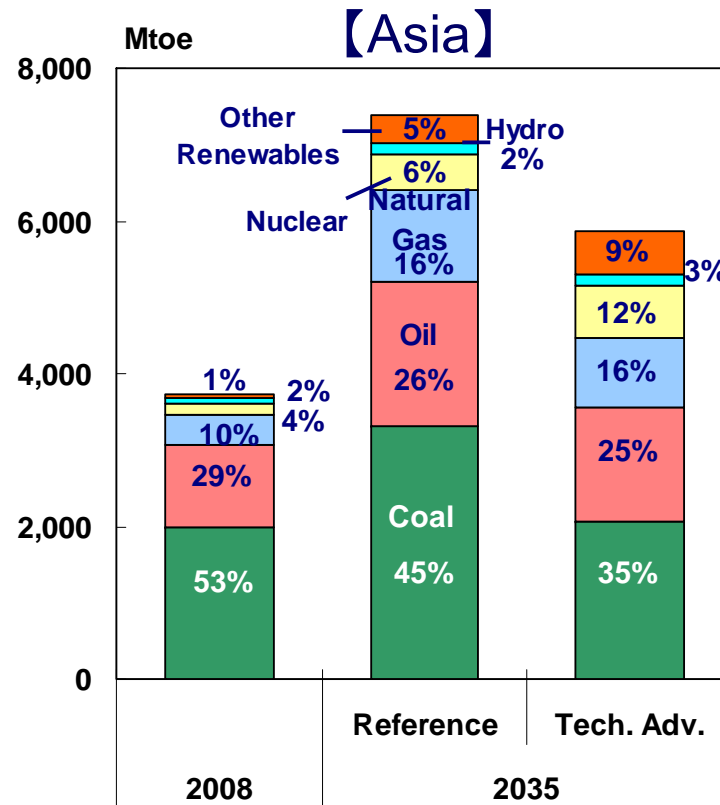
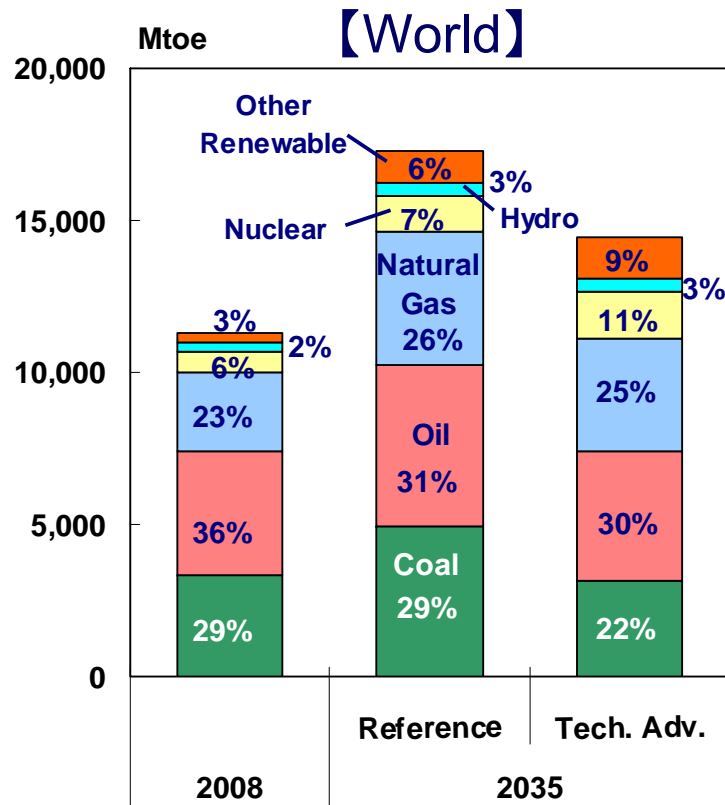
Primary Energy Mix (Asia)



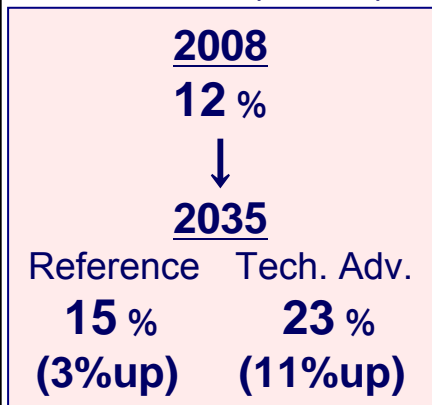
■ Coal will keep the biggest share of primary energy demand driven by the electric power demand through 2035. (The coal's share in Asia: 54% (2008) → 45% (2035) in Reference, 35% (2035) in Tech. Adv)

■ Natural gas in both scenarios will continue to grow. In the Tech. Adv. Scenario, the share of nuclear will gradually increase with active building-up of nuclear power plants in China, India, Japan and South Korea.

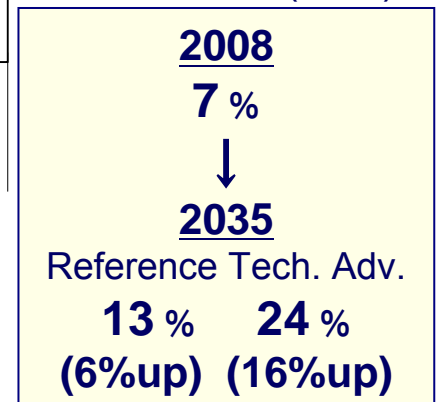
Primary Energy Mix (World, Asia)



Share of Non Fossil Fuel (World)

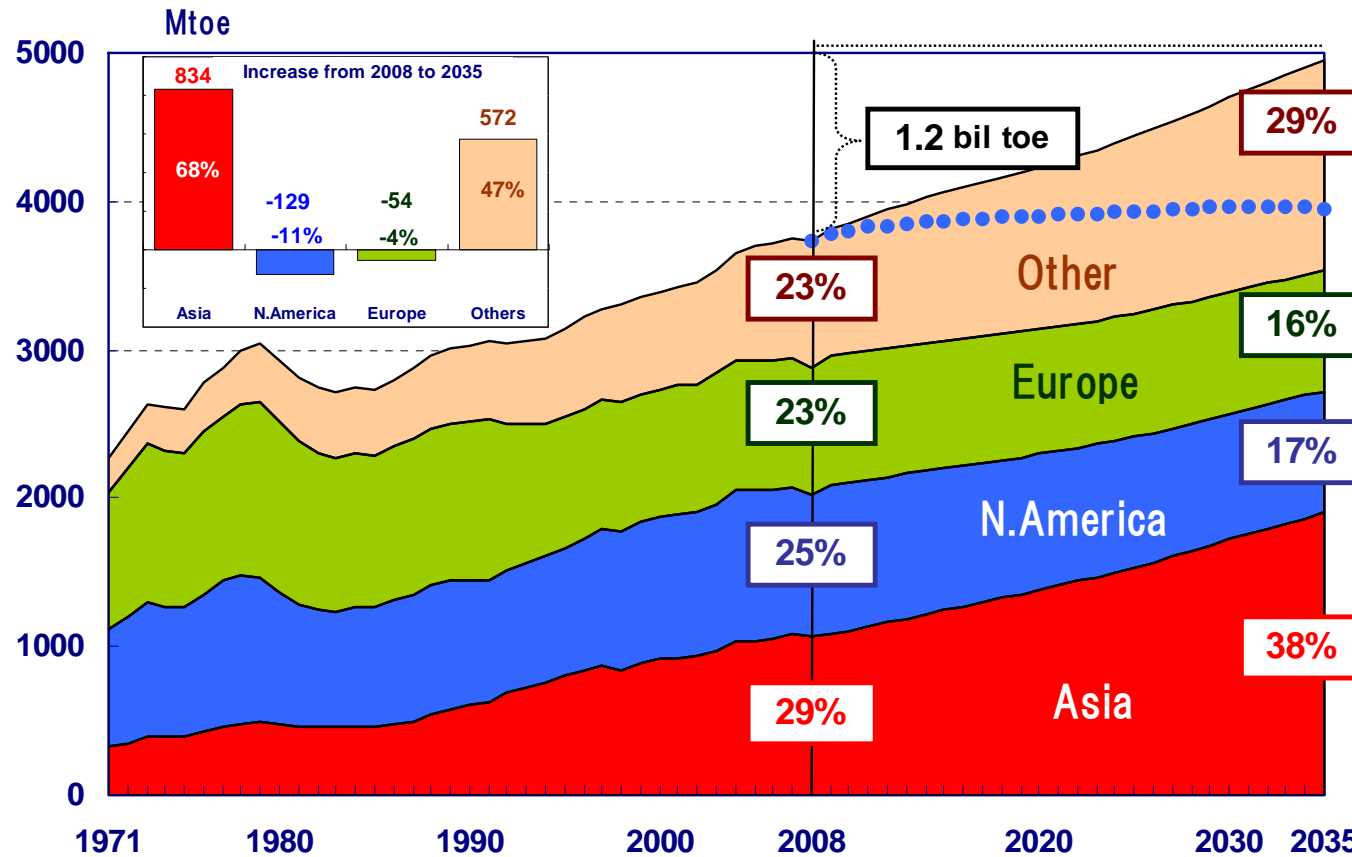


Share of Non Fossil Fuel (Asia)



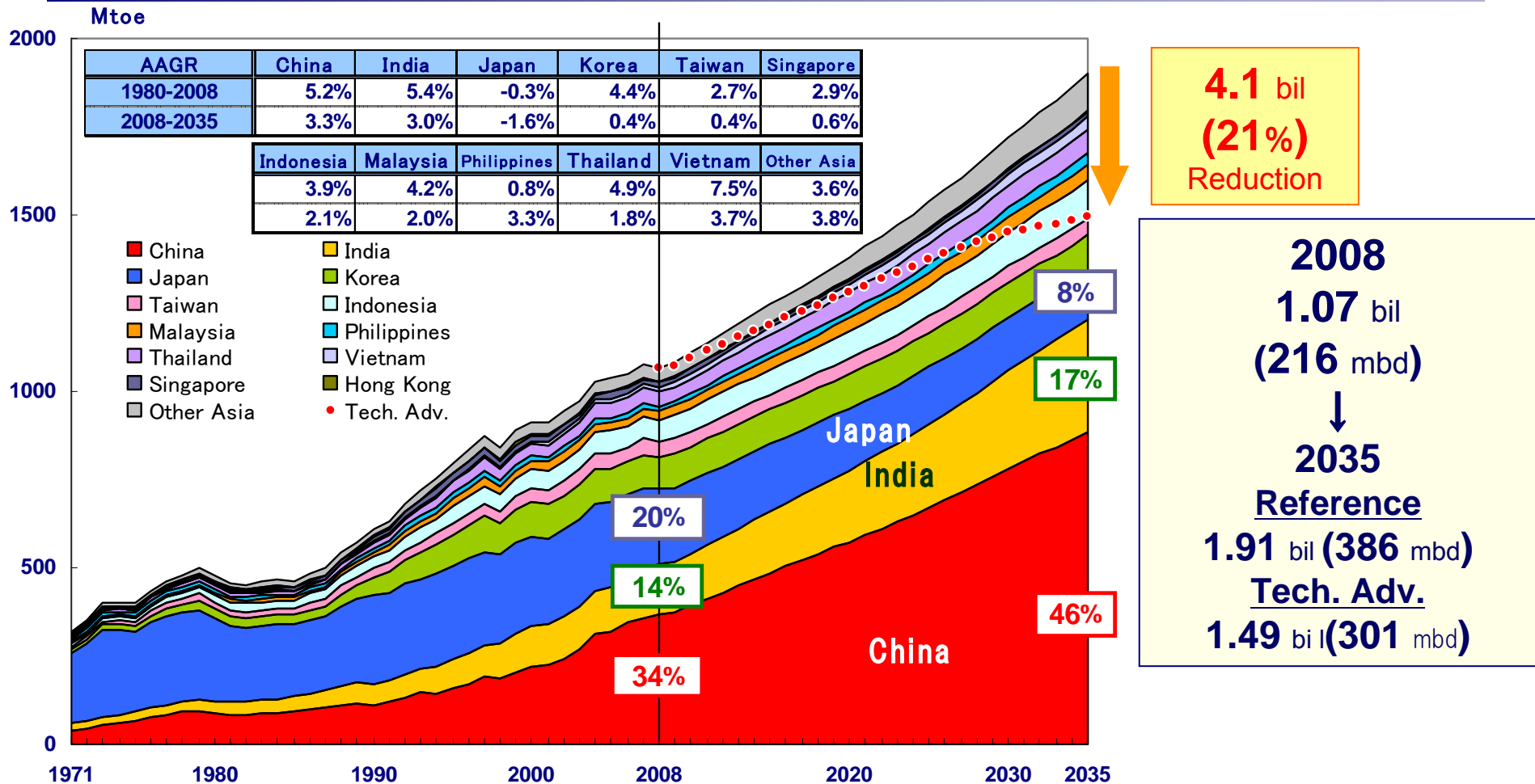
- In the Tech. Adv. Scenario, the share of non fossil fuel in the world energy demand will increase to 23% in 2035. Similarly, the share of non-fossil fuel in Asia will increase to 24%.
- In the Tech. Adv. Scenario, fossil fuel will continue to be the most important fuel in the world and Asia by 2035.

Oil Demand by Region (World)



- More than 70% of global oil growth will take place in Asia, and the share of Asia in the world oil demand will increase from 29% (2008) to 38% (2035). Asia will continue to lead the world oil demand growth by 2035.
- Oil demand in OECD started to decrease since 2005 and this trend will continue through 2035. The share of OECD will decrease from 50% in 2008 to 33% in 2035, while that of Non-OECD will increase to 67% in 2035.
- In the Tech. Adv. the world oil demand will peak in 2030 as a result of vehicle fuel efficiency improvement and shift to the other energy types in the power and industry sectors. Oil demand will be 0.99 billion ton (equal to 20% of reference) lower in 2035 compared with the Reference Scenario.

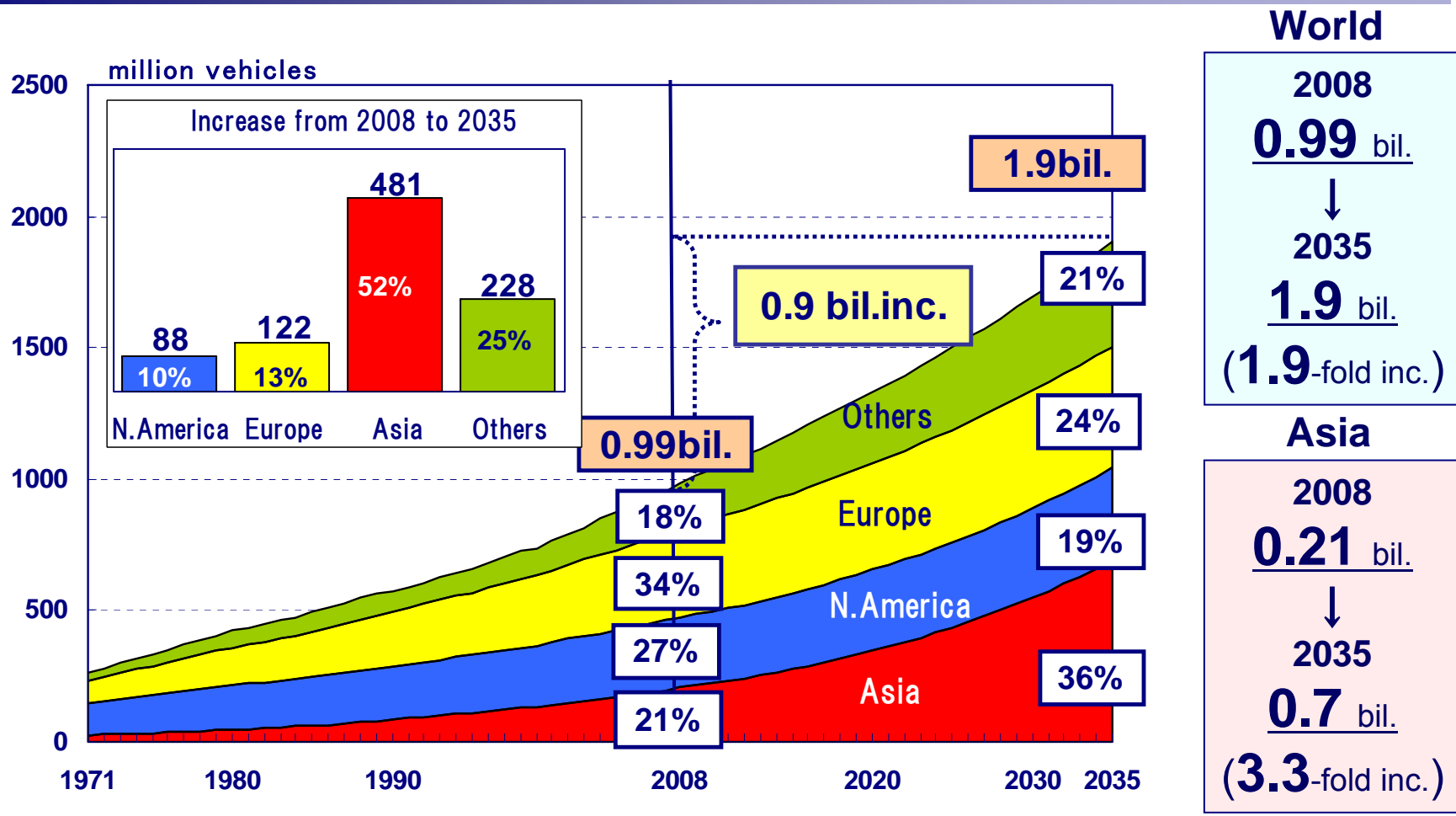
Oil Demand by Region (Asia)



■ Though the vehicles' fuel efficiency may be improved, and clean energy vehicles may expand, oil demand in China will expand from 7.4 million B/D in 2008 to 19.0 million B/D in 2035, due mainly to its escalating vehicle ownership. The share of China and India together in Asian oil demand will grow from 46% in 2008 to 61% in 2035.

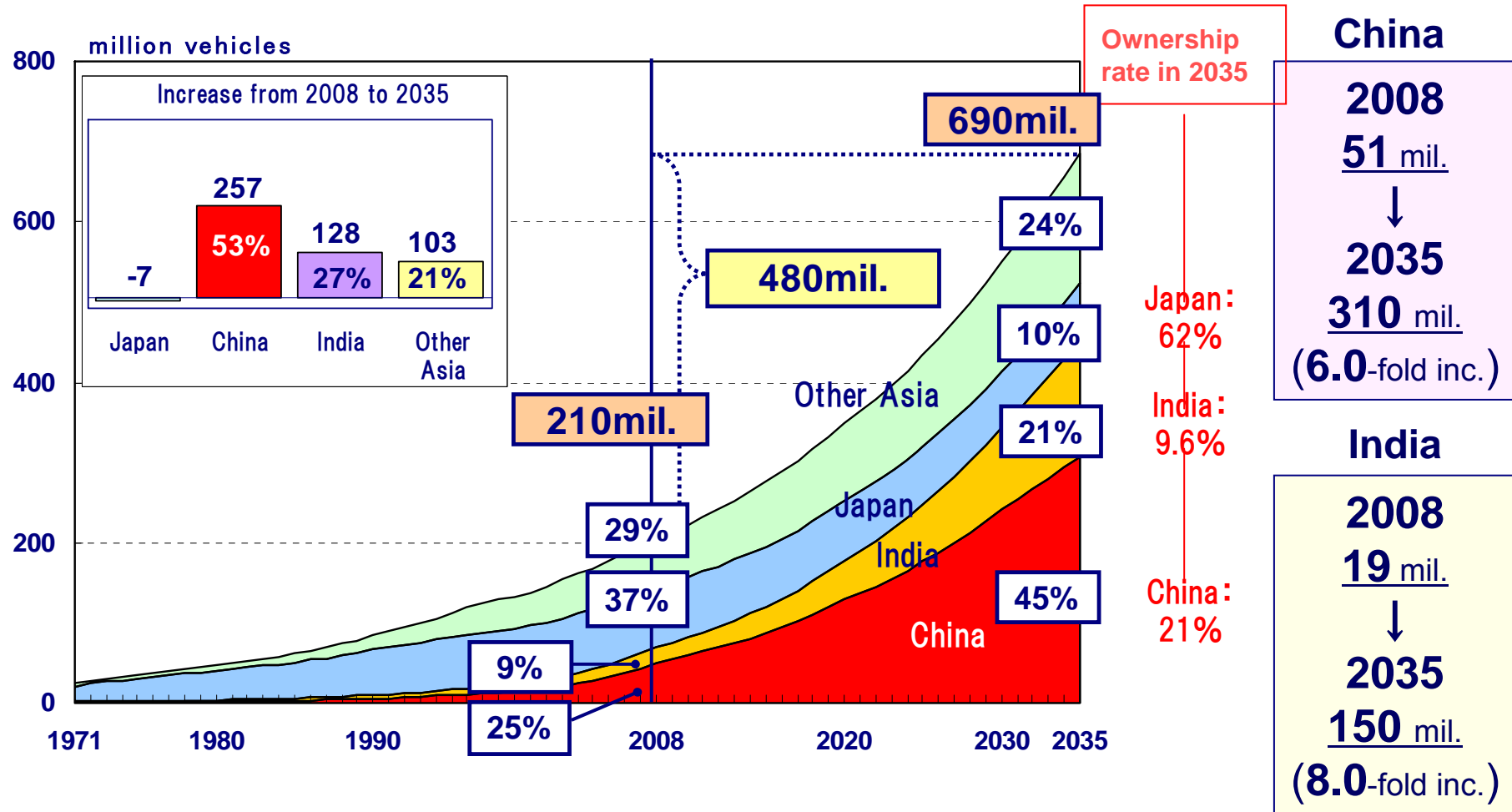
■ Even in the Tech. Adv. Scenario, oil demand will not peak out and grow continuously. Projected oil demand saving will be equal to 21% of the Reference Scenario in 2035.

The Number of Vehicles (World)



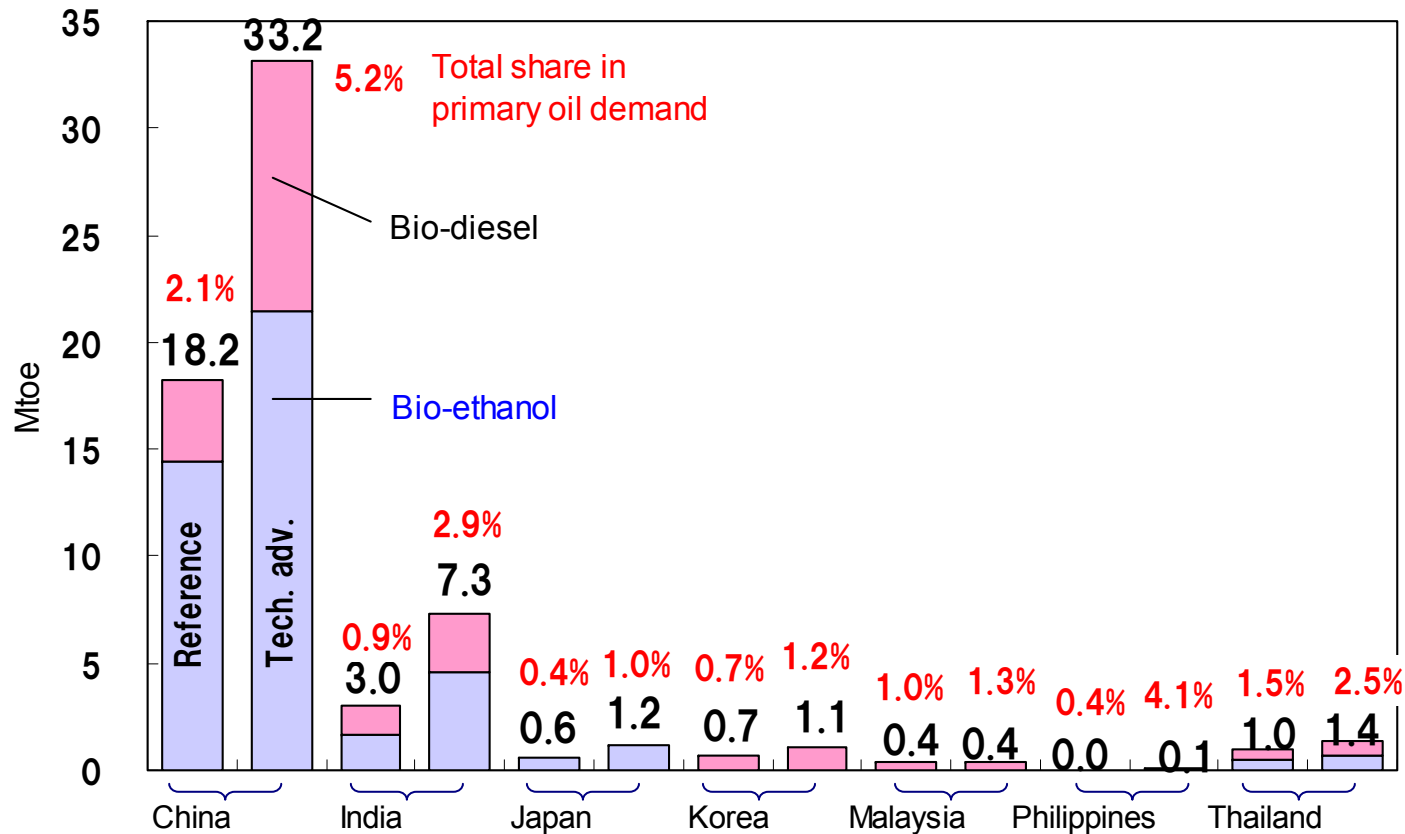
- Approximately 36% of the world vehicle stocks concentrates in Asia.
- The share of vehicle stocks in OECD will decline from 70% in 2008 to 47% in 2035. The stock in Non-OECD will surpass that of OECD by 2035.

The Number of Vehicles (Asia)



China and India's vehicle stocks will expand substantially.

Biofuel Outlook in Asia and the World (2035)



World

2008
49 mil. toe

↓

2035
160 mil. toe
(3.6-fold inc.)

Asia

2008
3 mil. toe

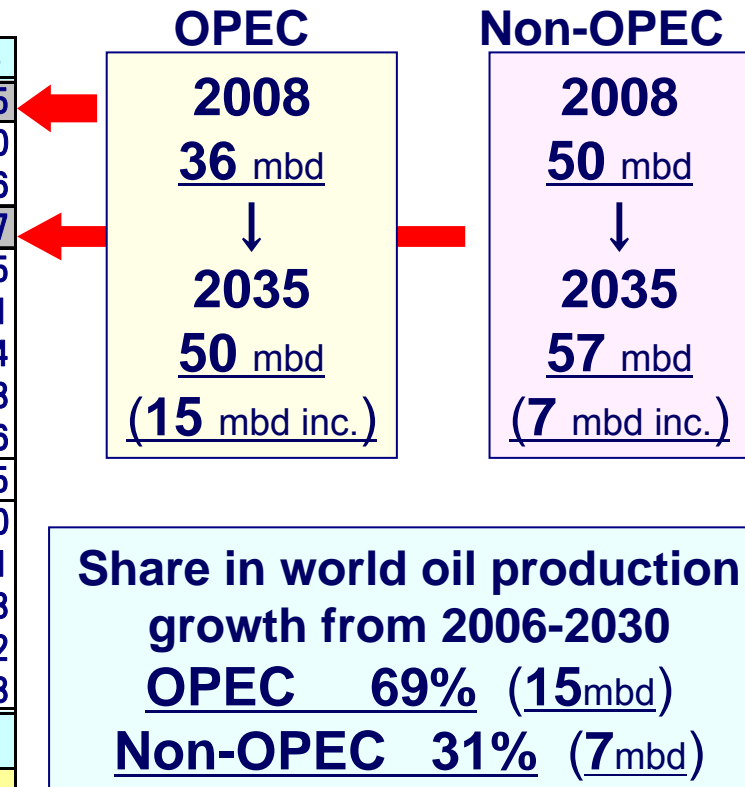
↓

2035
24 mil. toe
(9-fold inc.)

- In the Reference Scenario, the world biofuel demand is expected to reach 160 Mtoe by 2035 mainly driven by the growth in North America, Europe and Latin America. Asia will consume 24 Mtoe of bio-fuel by 2035. The share of bio-fuel in global liquid fuel will amount to 3% in 2035.
- In Asia, ethanol demand will mainly increase in China, India and Japan, while biodiesel will increase in Korea, Indonesia, and Malaysia.
- In the Tech. Adv. Scenario, the world bio-fuel demand will reach 270 Mtoe 2035, and that of Asia will reach 46 Mtoe.

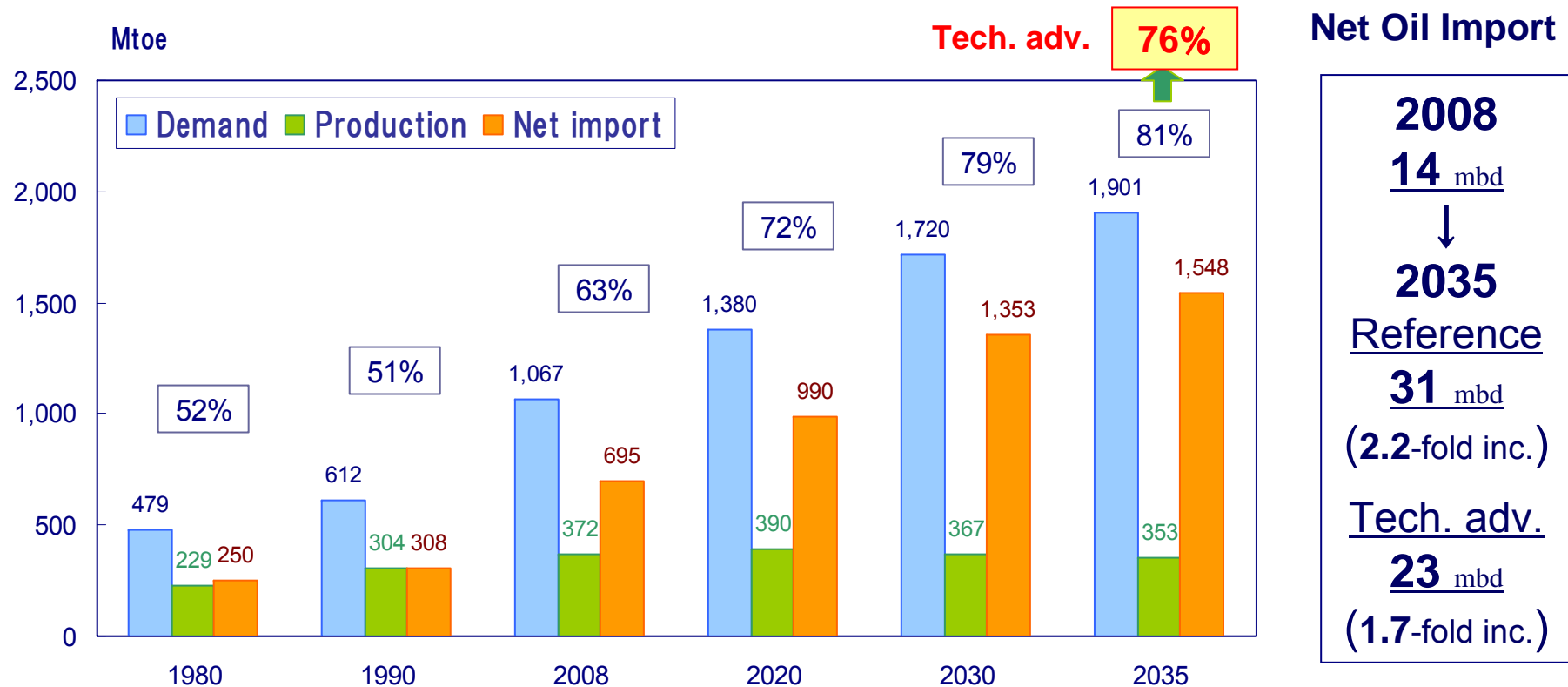
Oil Production Outlook

million b/d	2008	2020	2030	2035	2008-2035
OPEC	36	43	48	50	15
Middle East	24	30	33	34	10
Other OPEC	11	13	15	16	4.6
non-OPEC	50	50	54	57	6.7
N. America	15	14	16	16	1.5
L. America	4.3	5.8	7.2	8.4	4.1
Europe(inc. Russia)	18	17	18	19	1.4
Middle East	1.5	1.3	1.2	1.2	▲ 0.3
Africa	2.6	2.8	3.0	3.2	0.6
Asia	8.6	8.7	8.4	8.1	▲ 0.5
China	4.0	4.2	4.1	4.0	0.0
India	0.9	1.0	1.0	1.0	0.1
Indonesia	1.0	1.0	0.8	0.8	▲ 0.3
Malaysia	0.7	0.7	0.6	0.6	▲ 0.2
Thailand	0.4	0.1	0.1	0.1	▲ 0.3
World (ref.)	86	92	102	107	21
World (Tech. adv.)				87	1



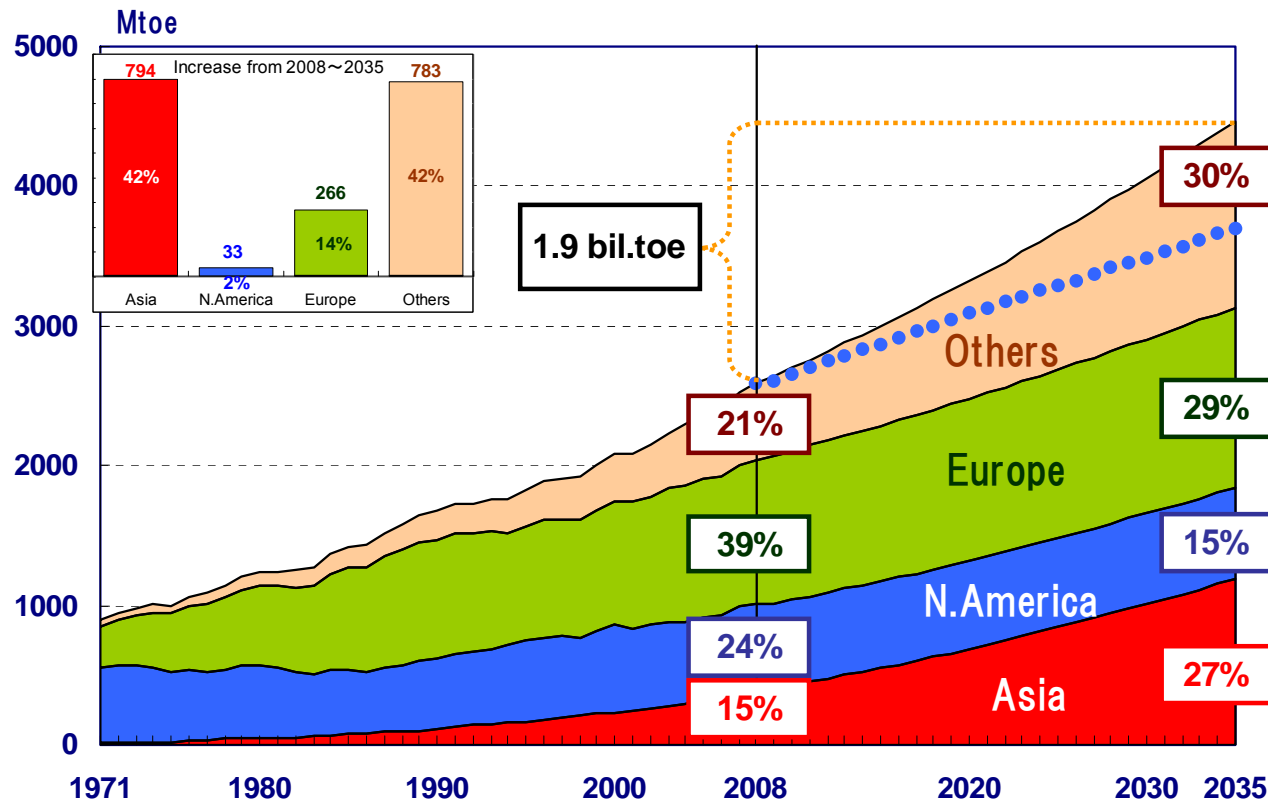
- In Asia, oil production is projected to decline at 0.5% per year through 2035.
- OPEC will account for approximately 70% of world oil production growth; the OPEC's share in the world oil production is likely to expand to 47% by 2035 from about 42% in 2008.
- In some OPEC countries in the Middle East, participation of international oil companies in the oil exploration and development projects has been bounded by political issues. Unless the adequate upstream investment is channeled, international oil market will become tightened in the future.

Oil Supply and Demand in Asia



- Net oil import in Asia will expand from 14 mb/d (695 Mtoe) in 2008 to 31 mb/d (1,548 Mtoe) in 2035.
- Oil production in Asia (such as China, India, Indonesia and Malaysia) will marginally increase, while oil demand will steadily increase. Therefore, net oil import ratio will reach 81% in the Reference Scenario, and 76% in the Tech. Adv. Scenario by 2035 (compared with 63% in 2008).

Natural Gas Demand by Region (World)



770 mil.
(17%)
Reduction

2008
2.6 billion toe
(2.9 trillion m³)
(2.1 bil.tonnes LNG)

↓

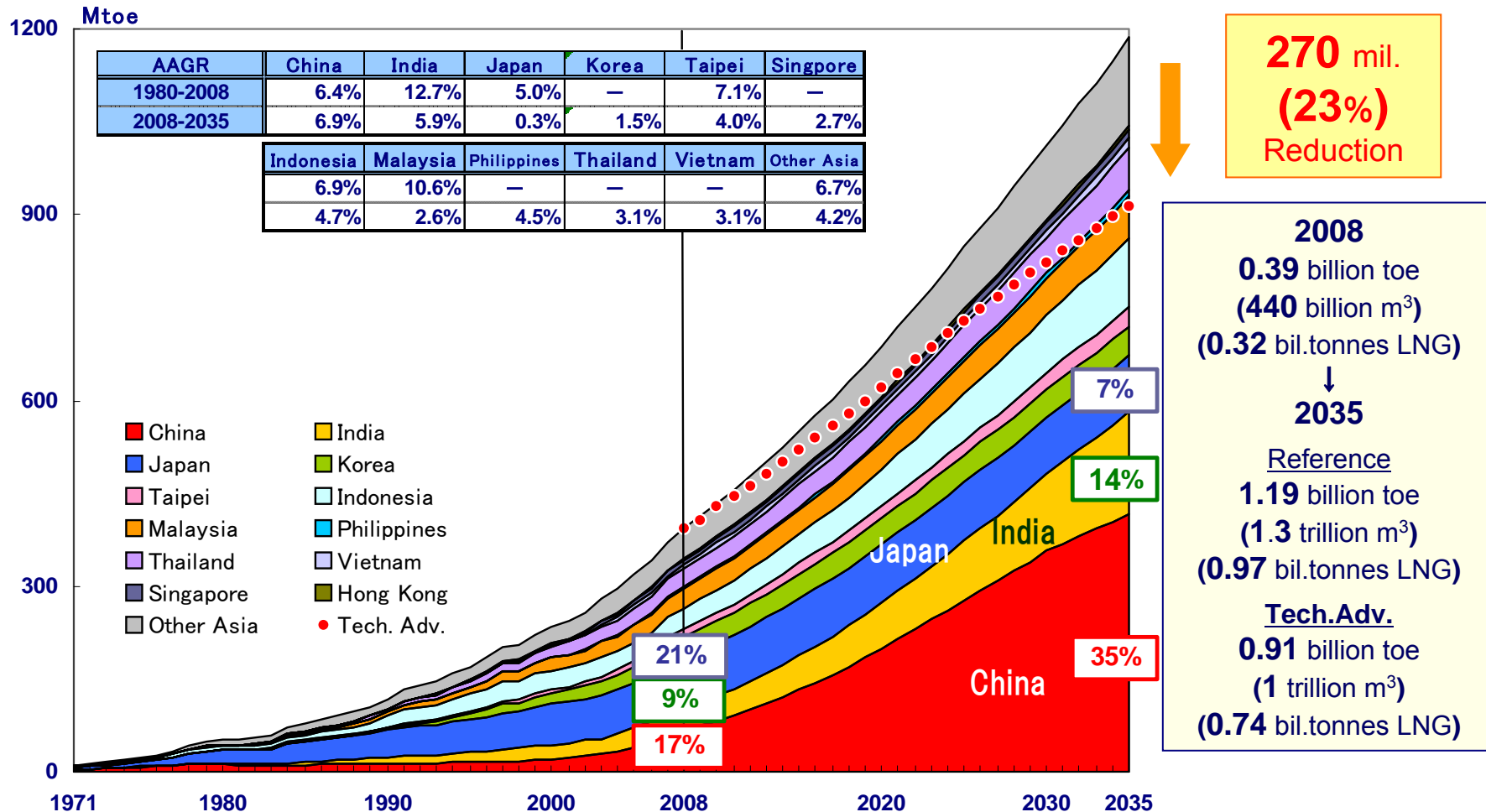
2035

Reference
4.5 billion toe
(5 trillion m³)
(3.6 bil.tonnes LNG)

Tech. Adv.
3.7 billion toe
(4.1 trillion m³)
(3.0 bil.tonnes LNG)

- The world natural gas demand is expected to increase from 2.9 trillion cubic meters (tcm) in 2008 to 5.0 tcm in 2035, a 1.7-fold increase.
- Of the incremental growth in the world natural gas demand from 2008 to 2035, Non-OECD will account for 86%.
- In the Tech. Adv. Scenario, natural gas demand will be 0.9 tcm lower than the Reference Scenario. Despite the projected saving, natural gas demand will continue to grow in the Tech. Adv. Scenario suggesting further needs of energy resources development.

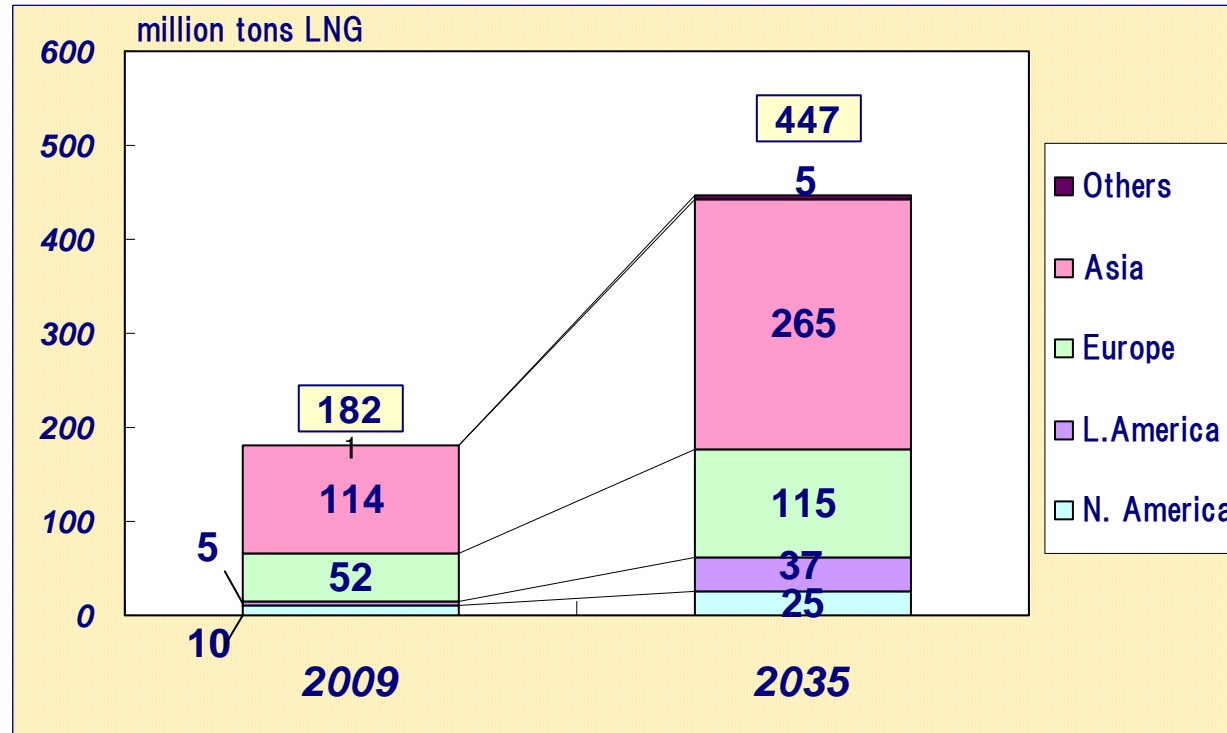
Natural Gas Demand by Country (Asia)



■ Natural gas demand in China will considerably increase due mainly to the increasing demand for power generation, and gas use in urban areas. India's natural gas demand will also expand, representing a five-fold increase from 2008 to 2035.

■ In the Tech. Adv. Scenario, the world natural gas demand will be 270 bcm (or 23%) lower than the Reference Scenario by 2035. Although substantial saving is projected in the Tech. Adv. Scenario, natural gas demand will increase at a relatively fast pace of 4.2% per year through 2035.

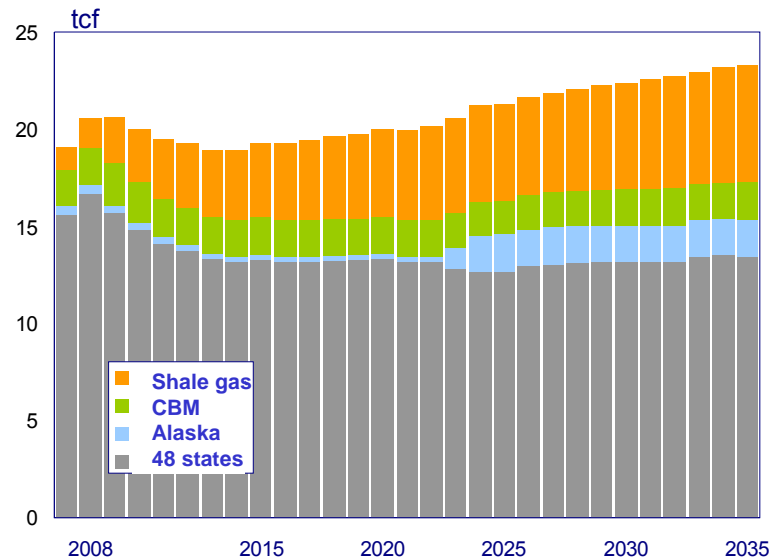
LNG Demand Outlook (World)



- World LNG demand will expand from 182 million tons in 2009 to 447 million tons in 2035, achieving a 2.5-fold increase.
- Asia's LNG demand will increase by 150 million tons, accounting for 57% of the world's LNG demand growth through 2035. Growth of LNG in Europe (63 million tons), and North America (15 million tons) will together account for 30% of the world LNG demand growth.

Outlook for unconventional natural gas

Natural gas production outlook for the United States



Source: DOE/EIA "Annual Energy Outlook 2010"

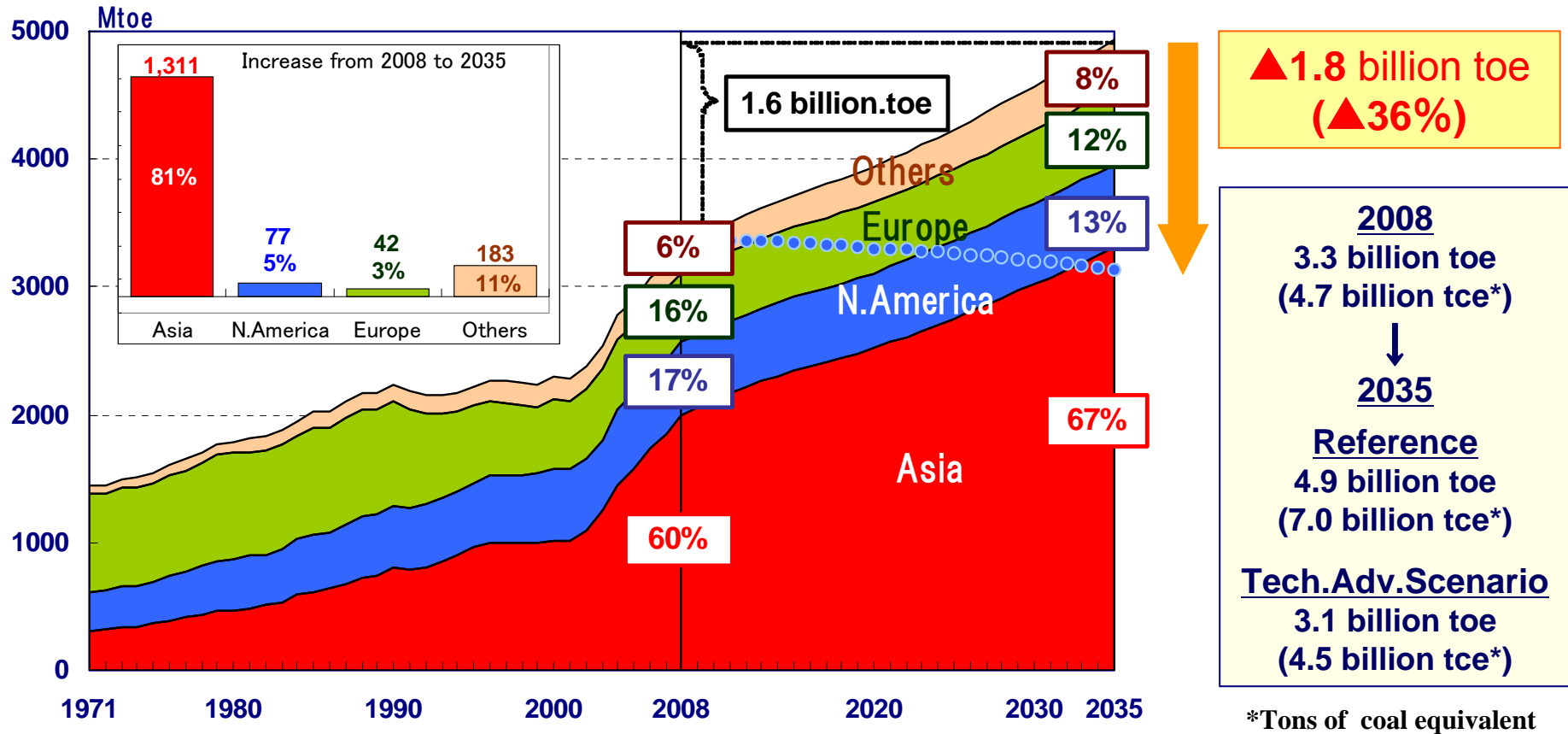
World unconventional natural gas resource potential

Tcf	Coalbed methane	Shale Gas	Tight-sand gas
N. America	3,017	4,471	1,371
L. America	39	373	1,293
Europe	275	1,118	431
Former USSR	3,957	5,402	901
Middle East / Africa	39	2,322	1,607
Asia / Oceania	1,724	1,117	1,803
World	9,051	14,803	7,406

Source: World Energy Council 2010
 "Survey of Energy Resources : Focus on Shale Gas",
 Kawata et al. (2001)

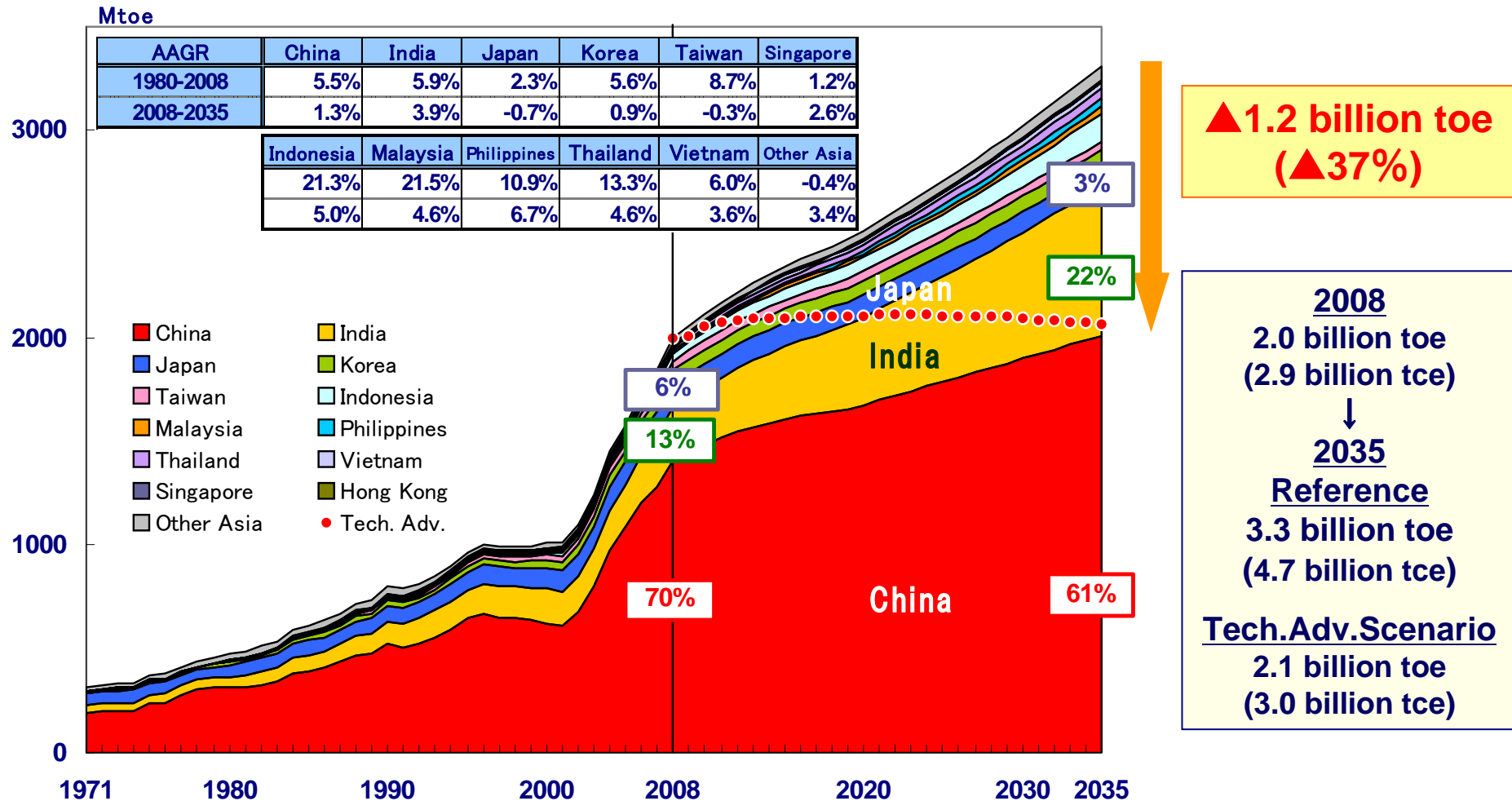
- Toward commercialization of unconventional natural gas, including shale gas and coal bed methane, research and development has been undertaken since 1960s in the US. Technological break through took place recently, increasing shale gas production at competitive price level with conventional natural gas. As a result, natural gas price in Europe and North America fell sharply.
- Shale gas resources are vastly located in the world, which are estimated at about 15,000Tcf. Assuming 40% of this resources are recoverable, it is comparable to the total proven reserves of conventional natural gas (about 189Tcm or 6,700Tcf).

Coal Demand by Region (World)



- Asia will account for 80% of the world coal demand growth through 2035, and the share of Asia in total coal demand will expand to 67% in 2035 from 60% in 2008.
- OECD is responsible for 6% of the world coal demand growth through 2035, and Non-OECD is responsible for 94%. The share of OECD in coal demand will decrease from 34% in 2008 to 25% in 2035, and Non-OECD will increase from 66% in 2008 to 75% in 2035.
- In the Tech. Adv. Scenario, the world coal demand in 2035 will be 1.8 billion toe (or 36%) lower compared with the Reference Scenario.

Coal Demand by Country (Asia)



■ Coal will be driven by the power sector in order to fuel substantial growth in electricity demand, mainly in China and India, both of which have abundant domestic coal reserves.

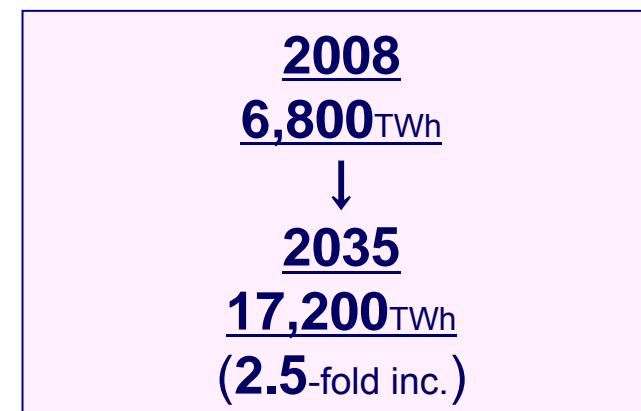
■ In the Tech. Adv. Scenario, Asian coal demand in 2035 will be 1.2 billion toe (or 37%) lower due to shift to natural gas and enhancement of power generation efficiency compared with the Reference Scenario.

Electricity Demand (Asia)

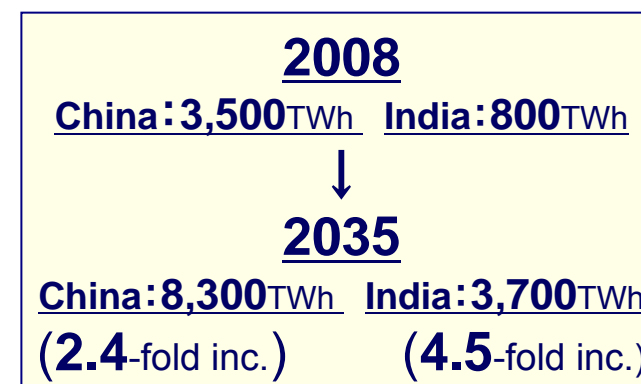
Reference 
Tech. Adv.

AAGR(%) (2008-2035)	Electricity Demand		Total Final Energy Demand	
	Reference Scenario	Tech. Adv. Scenario	Reference Scenario	Tech. Adv. Scenario
China	3.5	2.7	2.7	1.8
India	5.9	5.3	3.9	3.2
Korea	1.6	1.3	0.9	0.6
Indonesia	5.6	5.0	3.8	3.5
Malaysia	4.8	4.1	2.8	2.1
Thailand	4.0	3.2	2.6	2.4
Philippines	5.3	4.8	4.1	3.7
Asia(exc.Japan)	3.8	3.1	2.8	2.2
Japan	0.8	0.3	-0.3	-0.8
OECD	1.2	0.7	0.1	-0.4
Non-OECD	3.7	3.0	2.6	2.0
World	2.5	1.9	1.5	1.0

Asia



China / India

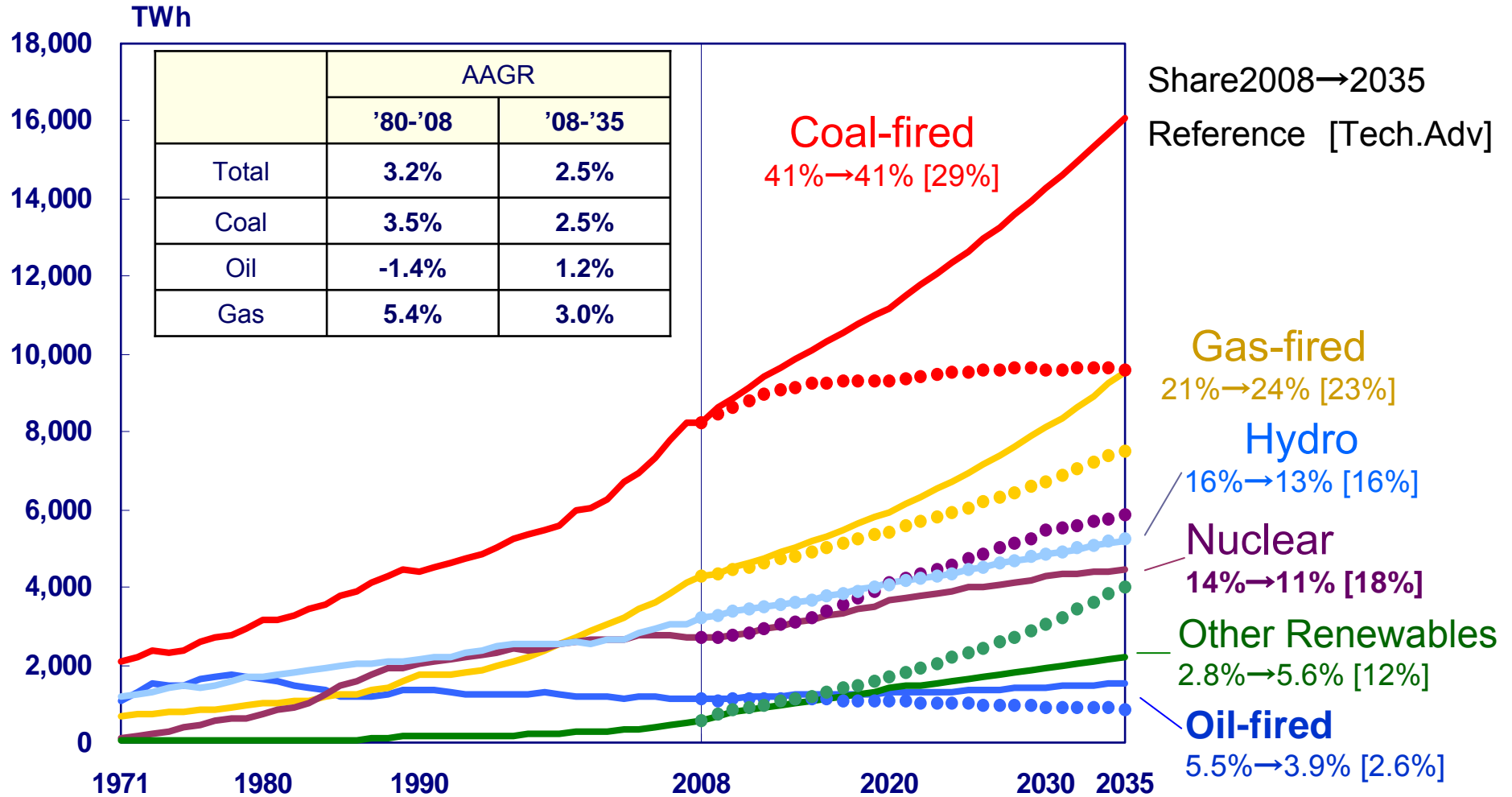


- Electricity demand in Asia will increase rapidly driven by the improvement of living standards.
- Through 2035, electricity demand will increase at a faster rate than final energy demand (Reference Scenario at 2.5% per year, and Tech. Adv. Scenario at 1.9% per year).
- OECD will account for about 20% of the world electricity demand growth, and Non-OECD will account for the remaining 80% through 2035.

Power Generation Mix by Fuel (World)

Solid line: Reference Scenario

Dotted line: Tech. Adv. Scenario



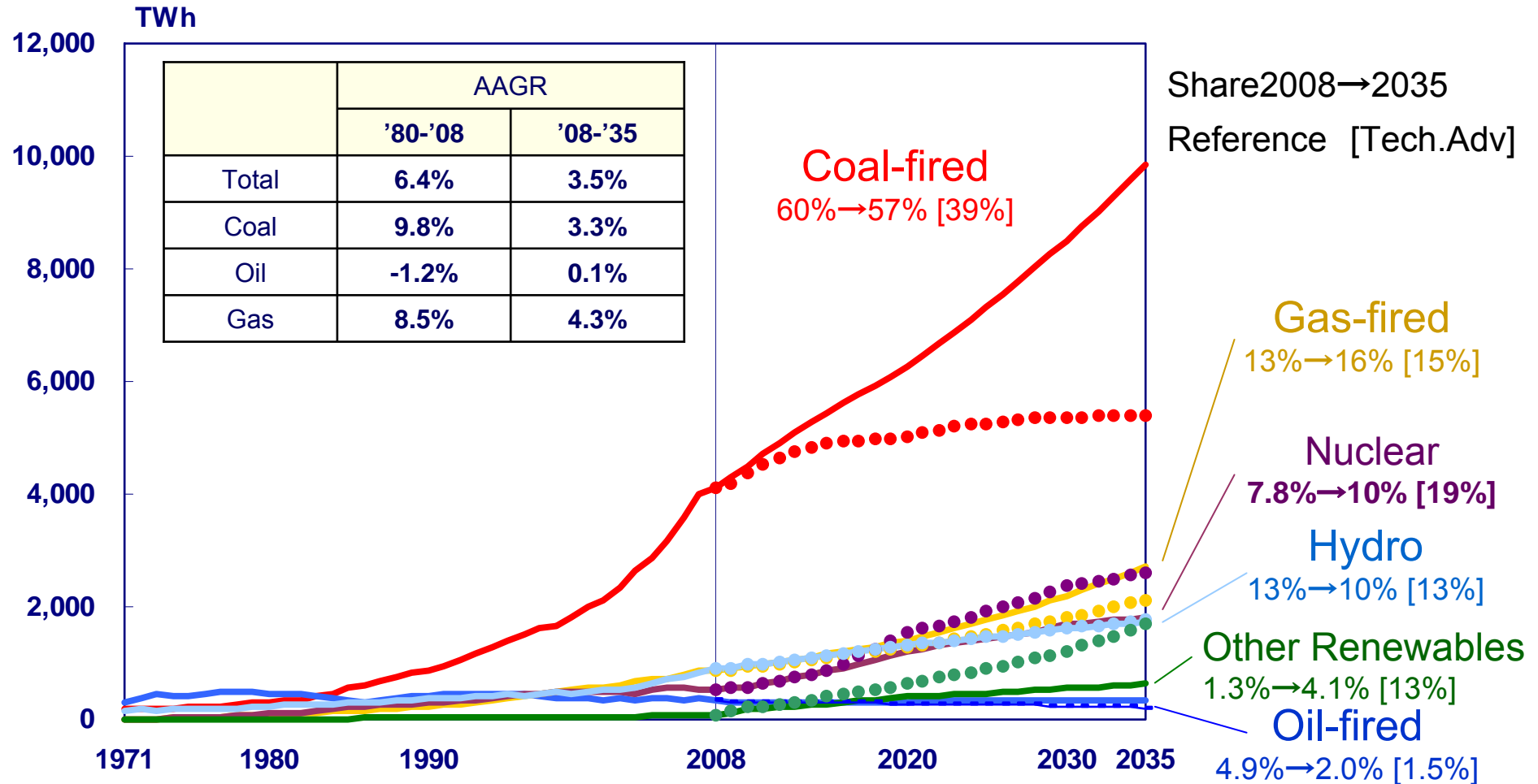
■ In the Reference Scenario, coal-fired generation will continue to dominate power generation mix by 2035. Natural gas-fired generation is projected to increase significantly at the highest rate among fossil fuels. The CO₂ emissions growth from coal-fired generation will account for 40% of the world CO₂ emissions growth in 2035.

■ In Tech. Adv. Scenario, the share of coal-fired generation in 2035 will decline to 29%, and the share of nuclear and renewables will expand.

Power Generation Mix by Type (Asia)



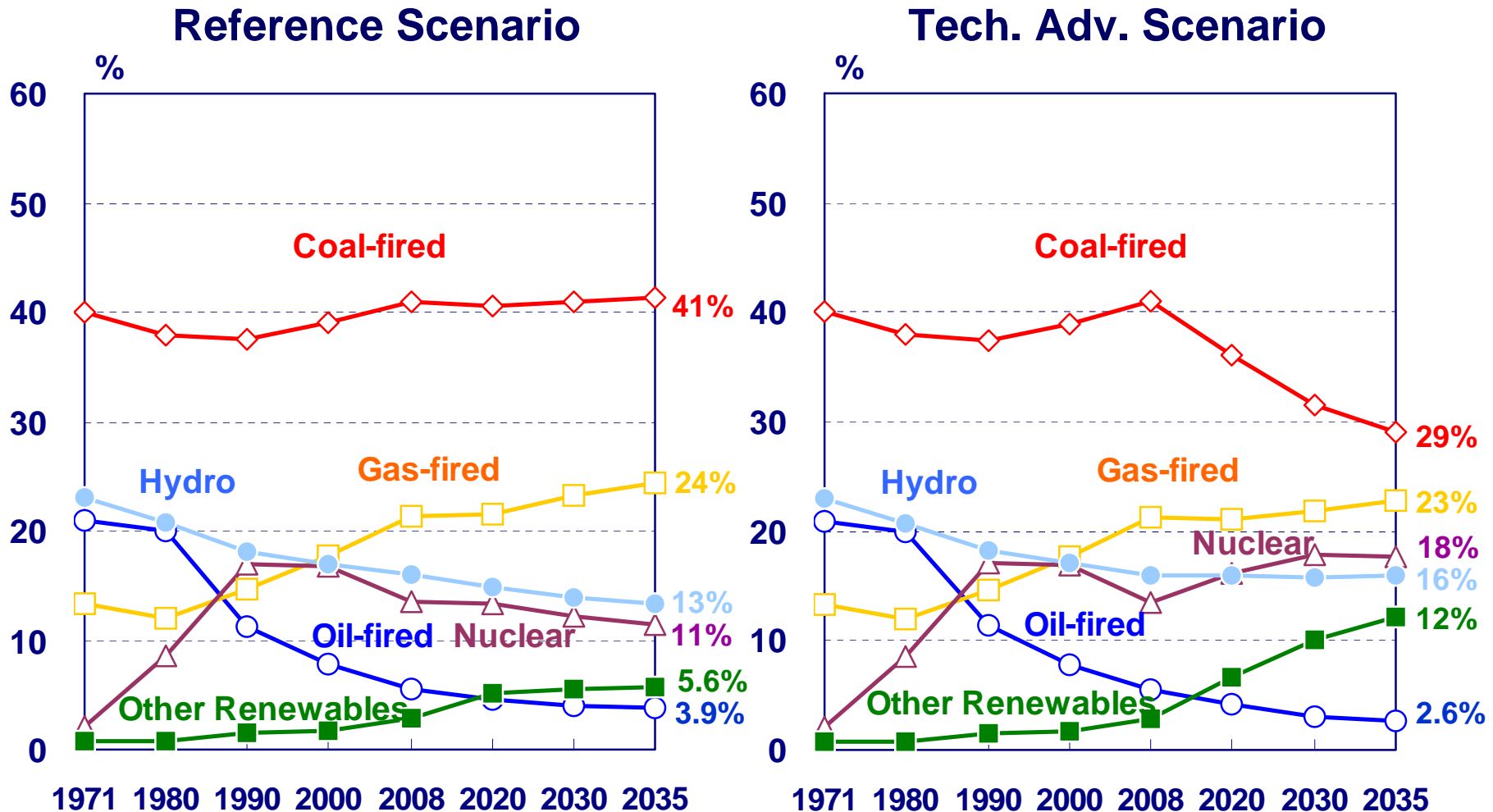
Solid line: Reference Scenario
Dotted line: Tech. Adv. Scenario



■ The Asia's share of coal in generation mix will remain higher than 50%, reflecting resources availability and coal's cost competitiveness against other energy sources. The share of natural gas will increase from 12.8% in 2008 to 16% in 2035. The share of nuclear power generation will increase from 7.8% in 2008 to 10.5% in 2035.

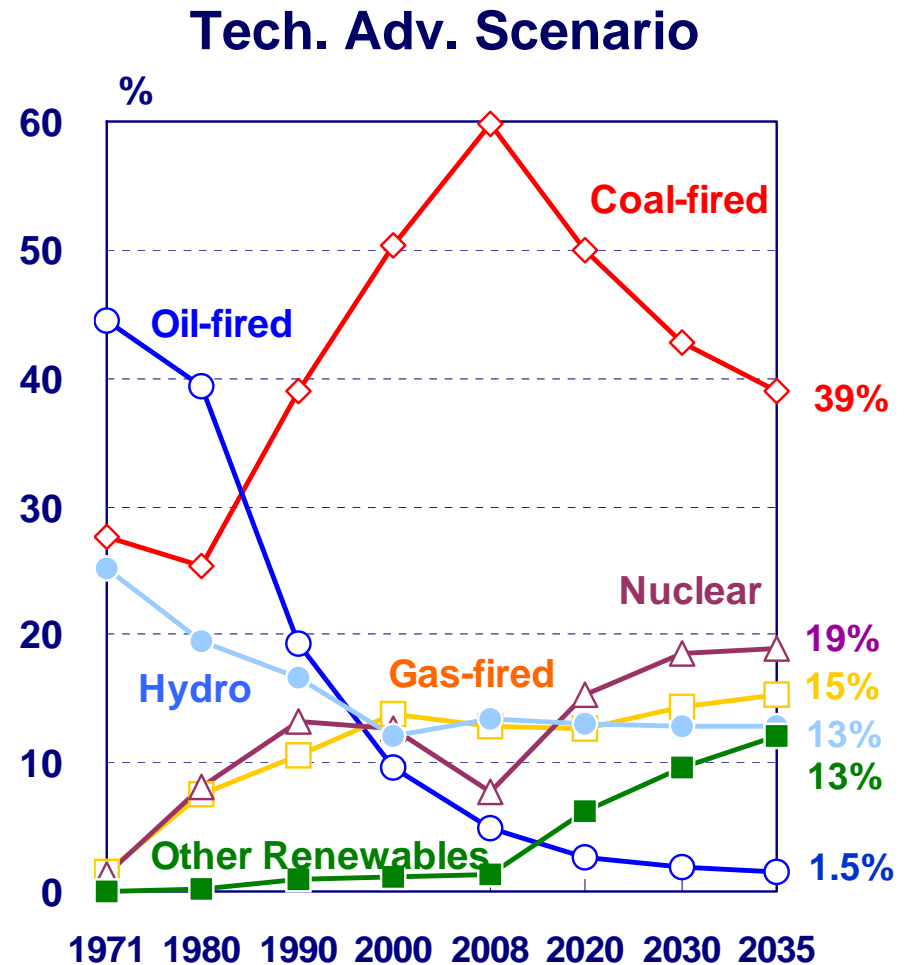
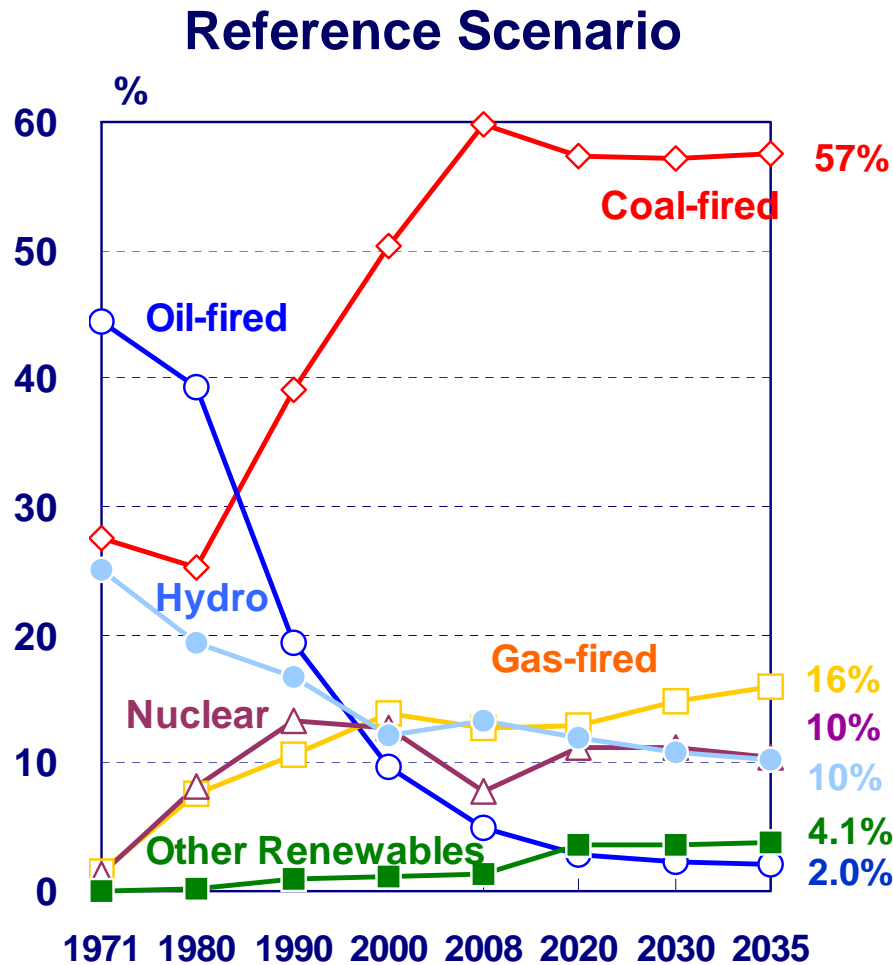
■ In the Tech. Adv. Scenario, the share of coal will decline from 60% in 2008 to 39% in 2035, and clean coal technology (CCT) is expected to play an important role in addressing global warming issues.

Power Generation Mix by Fuel (World)



- Coal-fired generation will maintain the biggest share in the power generation mix by 2035.
- In the Tech. Adv. Scenario, the share of coal-fired generation will decrease greatly, while that of renewable energy and nuclear will increase.

Power Generation Mix by Fuel (Asia)

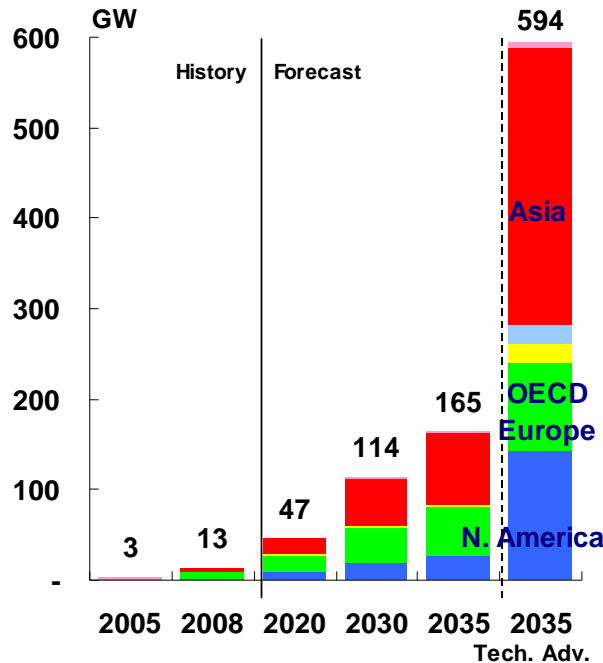


■ In Asia, the share of coal-fired generation will increase to meet growing electricity demand.

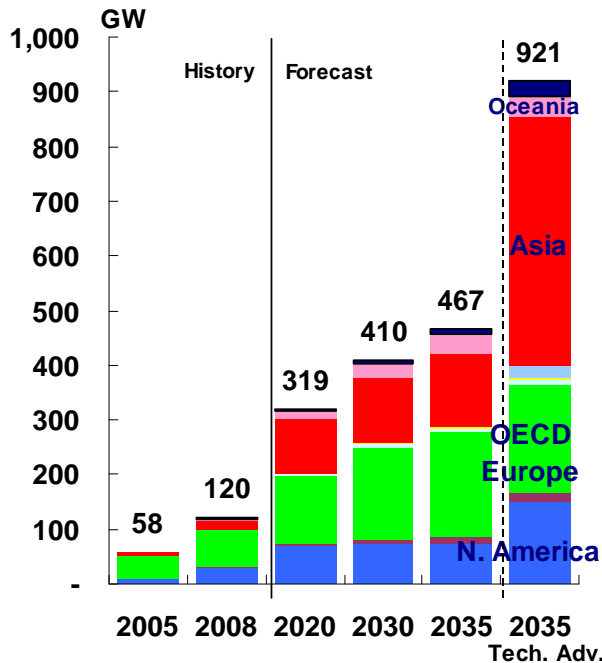
■ In the Tech. Adv. Scenario, the share of coal-fired generation will decrease substantially, which will be substituted by the increases in renewable energy and nuclear share.

Photovoltaic, Wind Power (World)

Photovoltaic (PV)

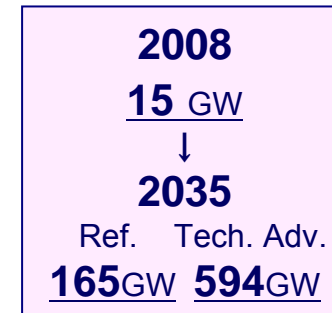


Wind Power



Photovoltaic (PV)

World

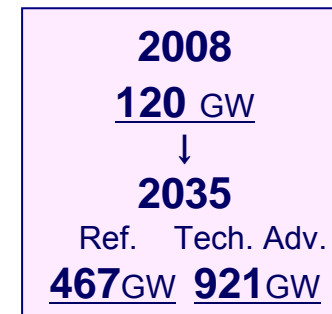


Asia

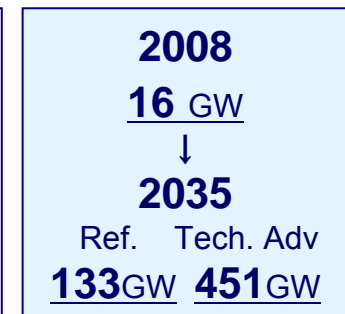


Wind Power

World

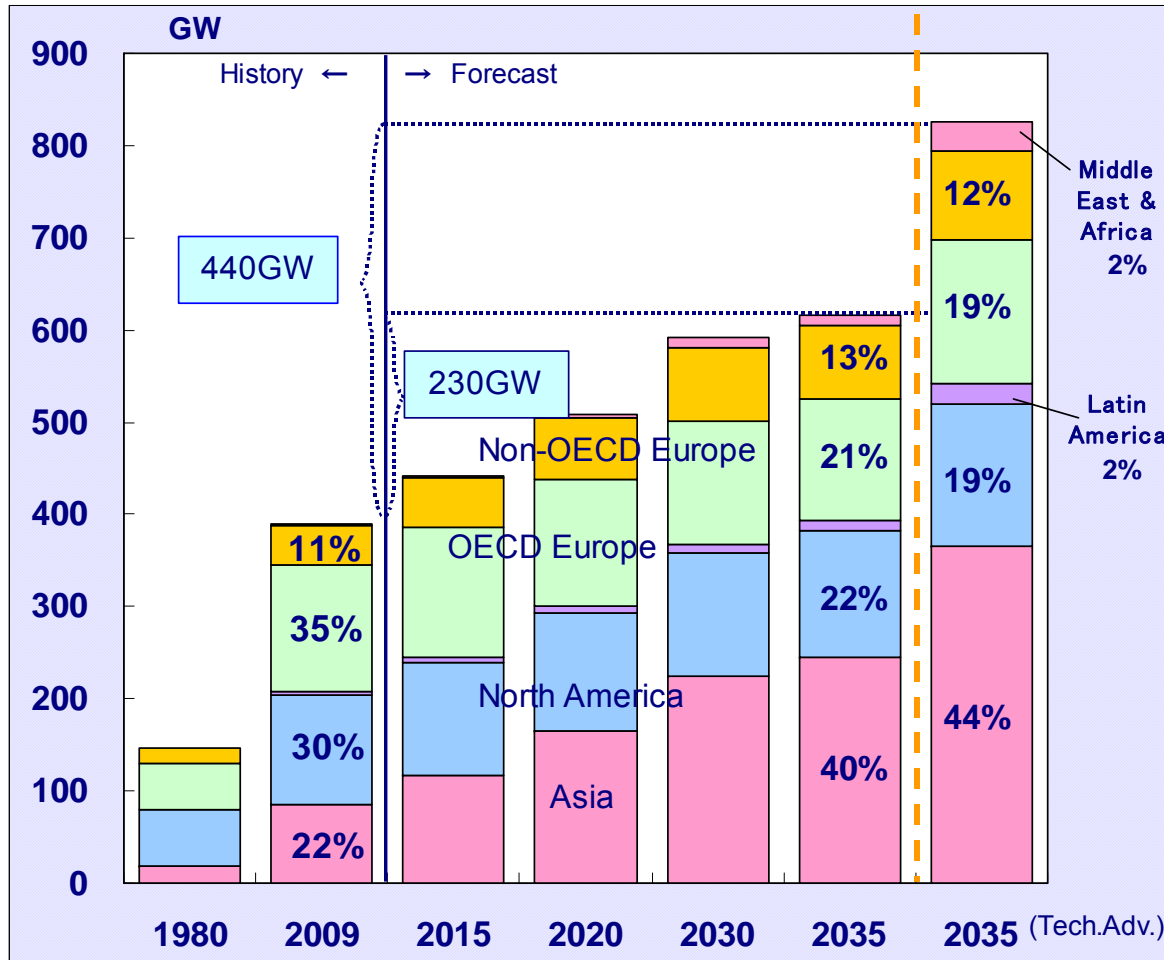


Asia



- Renewables are expected to expand due to technological advancement and supportive political measures such as feed-in tariff and subsidization.
- World PV generating capacity will grow to 165GW by 2035 and world wind power capacity will boost to 467 GW by 2035 both under the Reference Scenario.
- The share of power generation from wind and PV together in total global power generation will grow from 1.2% in 2008 to 3.2% in 2035 in the Reference Scenario, and 4.4% in the Technologically Advanced Scenario.

Nuclear Power Generation Capacity (World)



World

2009
389 GW

↓

2035

Reference Scenario
615 GW
(**226 GW increase**)

Tech. Adv. Scenario
826 GW
(**437 GW increase**)

- Nuclear capacity is projected to grow from 389 GW in 2009 to 615 GW in 2035 (226 GW increments). The largest increase in the nuclear capacity is expected in Asia (153 GW increments).
- Further increase in nuclear capacity is expected in the Tech. Adv. Scenario, reaching 826 GW in 2035.

Nuclear Power Capacity in Asia

(GW)

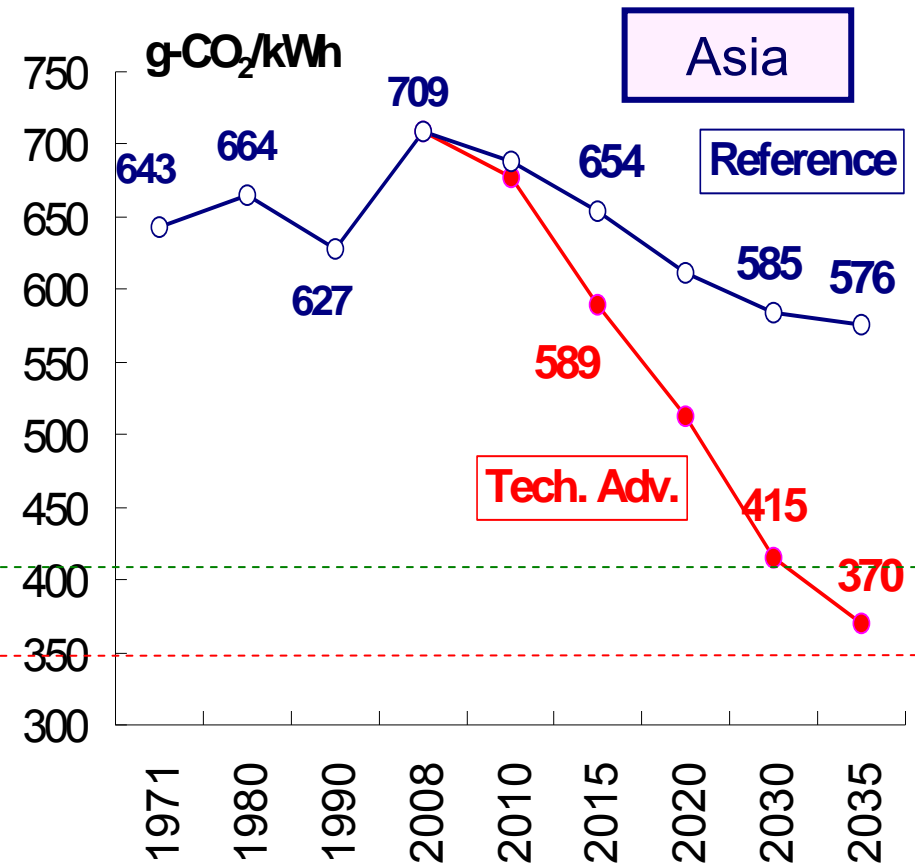
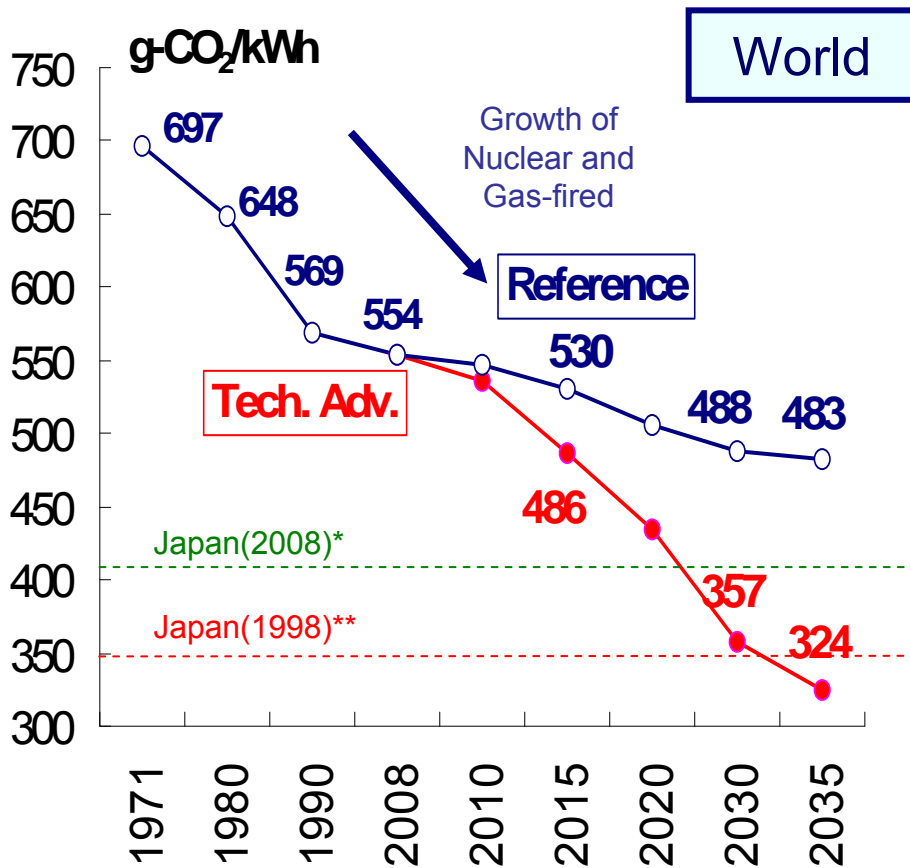
	2009	2020		2030	
		Reference Scenario	Tech. Adv. Scenario	Reference Scenario	Tech. Adv. Scenario
China	9	48	80	80	130
Japan	49	62	62	68	68
Taiwan	8	8	8	6	8
Korea	18	27	32	30	46
ASEAN	0	0	0	4	18
India	4	20	26	33	85
Asia	85	165	210	224	366

■Currently in Asia, nuclear power plants are operational in India, Pakistan, China, Korea, Taiwan and Japan. Other countries such as Vietnam, Indonesia and Thailand are considering to build nuclear power plants as strategy to ensure energy supply security.

■In the Tech. Adv. Scenario, nuclear power capacity in China will expand to 80 GW in 2020 - the largest in Asia.

■Nuclear power capacity in India will increase using the overseas light-water nuclear reactor technologies in addition to domestically developed thorium fuel cycle.

Carbon Intensity of Electricity (CO₂ Emissions per kWh)

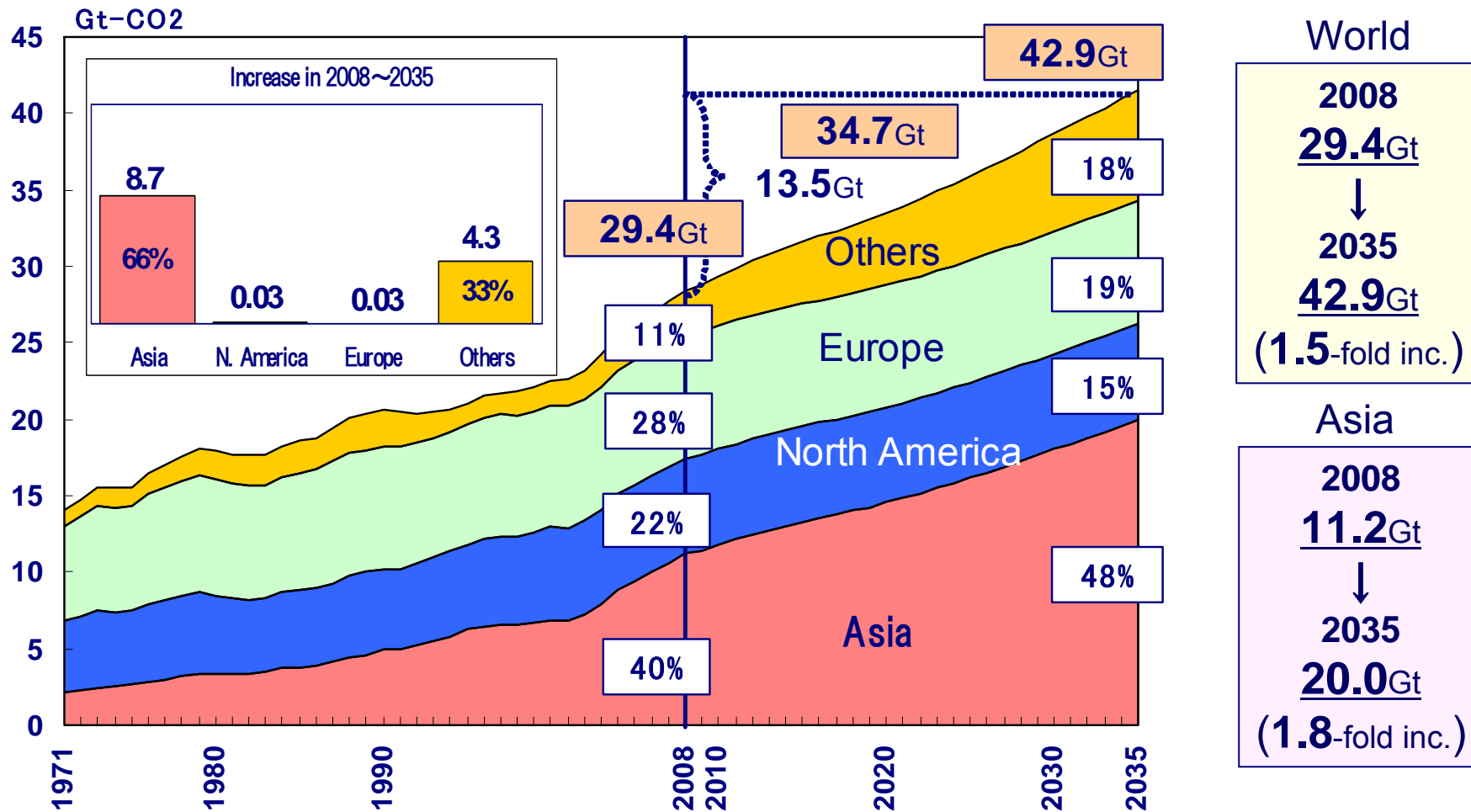


*410g-CO₂/kWh **350g-CO₂/kWh

■ In the Tech. Adv. Scenario, CO₂ emissions per kWh will be reduced substantially at the back of assumed expansions of nuclear and renewable energy in addition to the efficiency improvement of fossil-fired power generation.

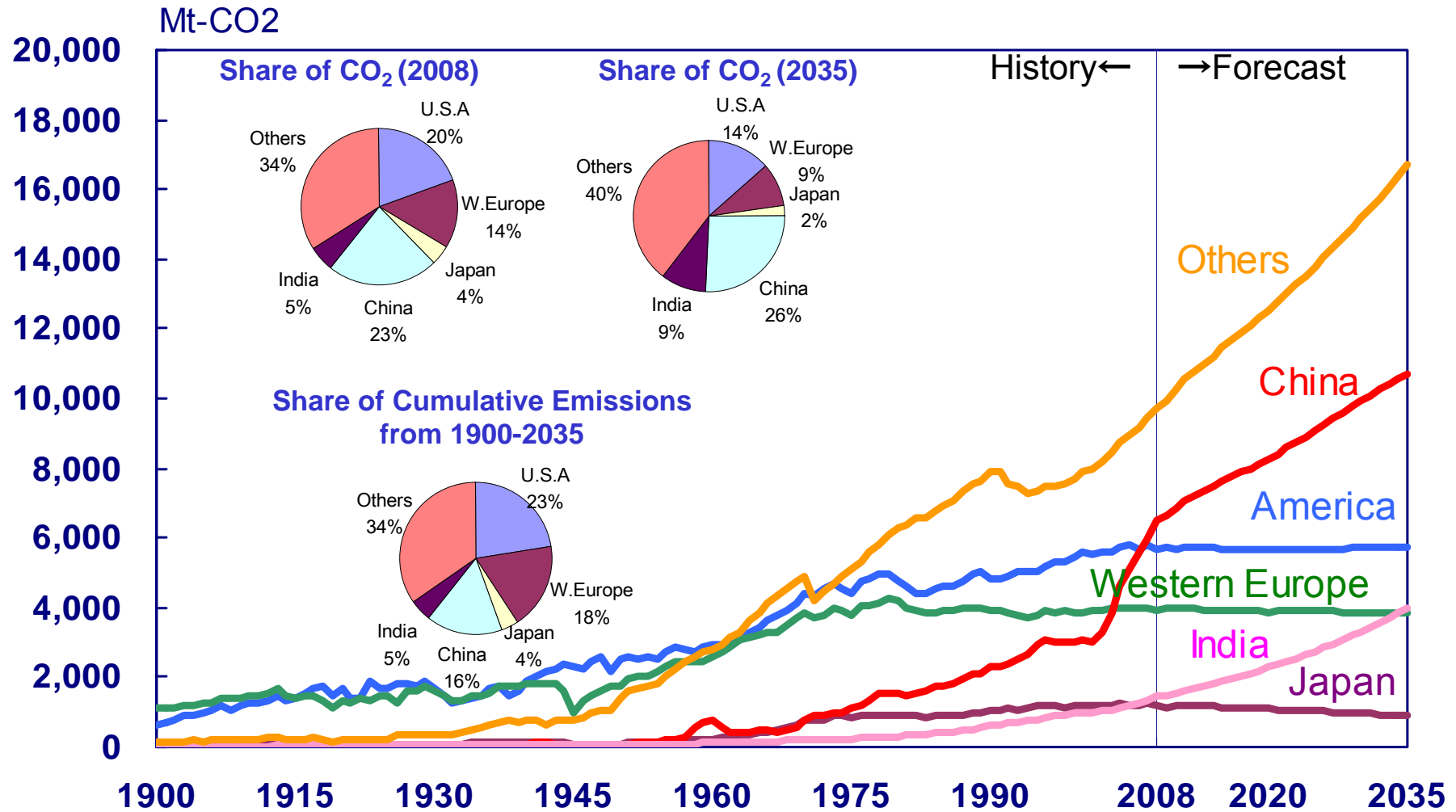
CO₂ Emission by Region (World)

Reference



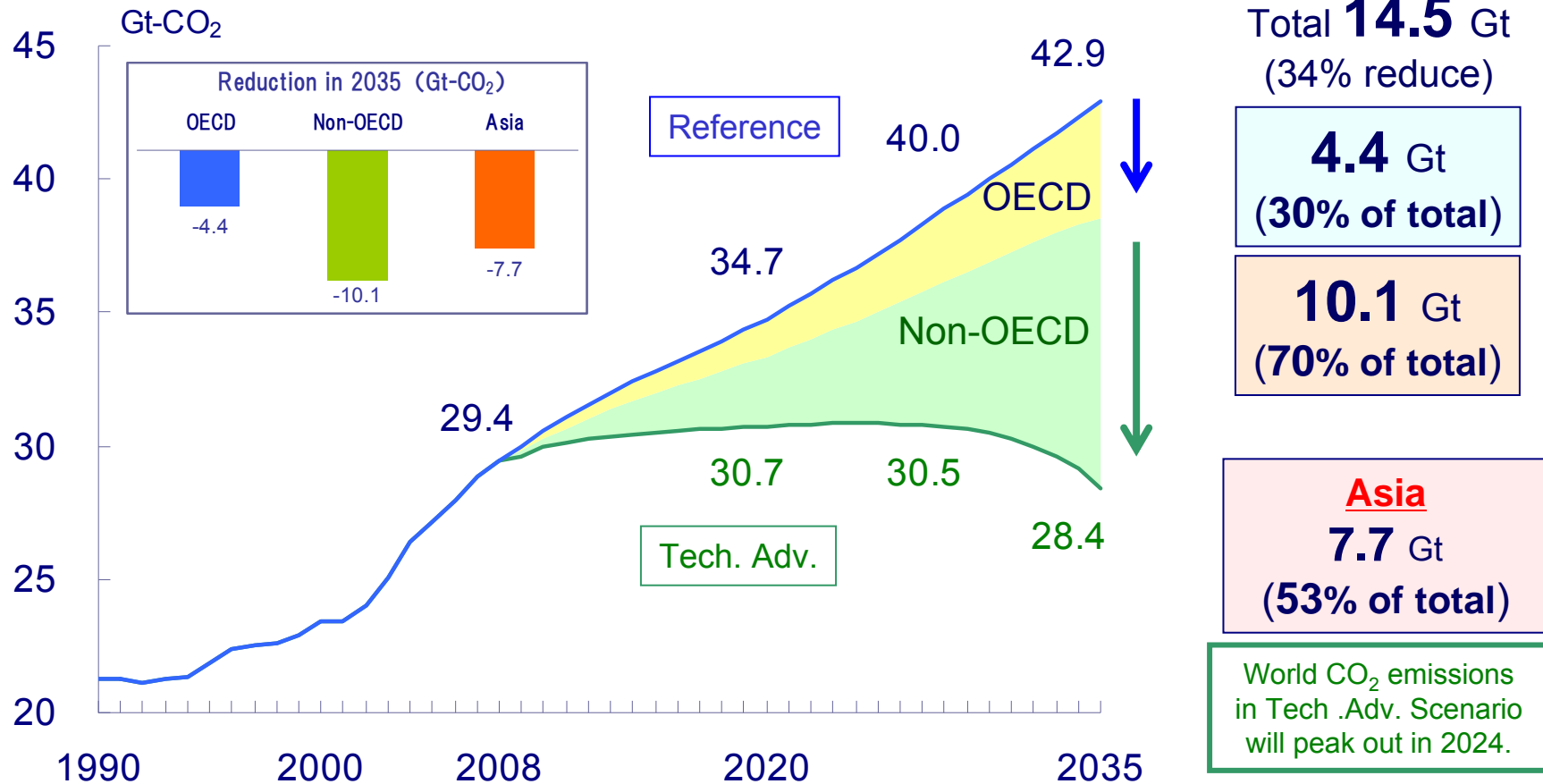
- Asia will account for 66% of global CO₂ emissions growth through 2035.
- The share of OECD will decrease from 44% in 2008 to 31% in 2035.

CO₂ Emissions (World)



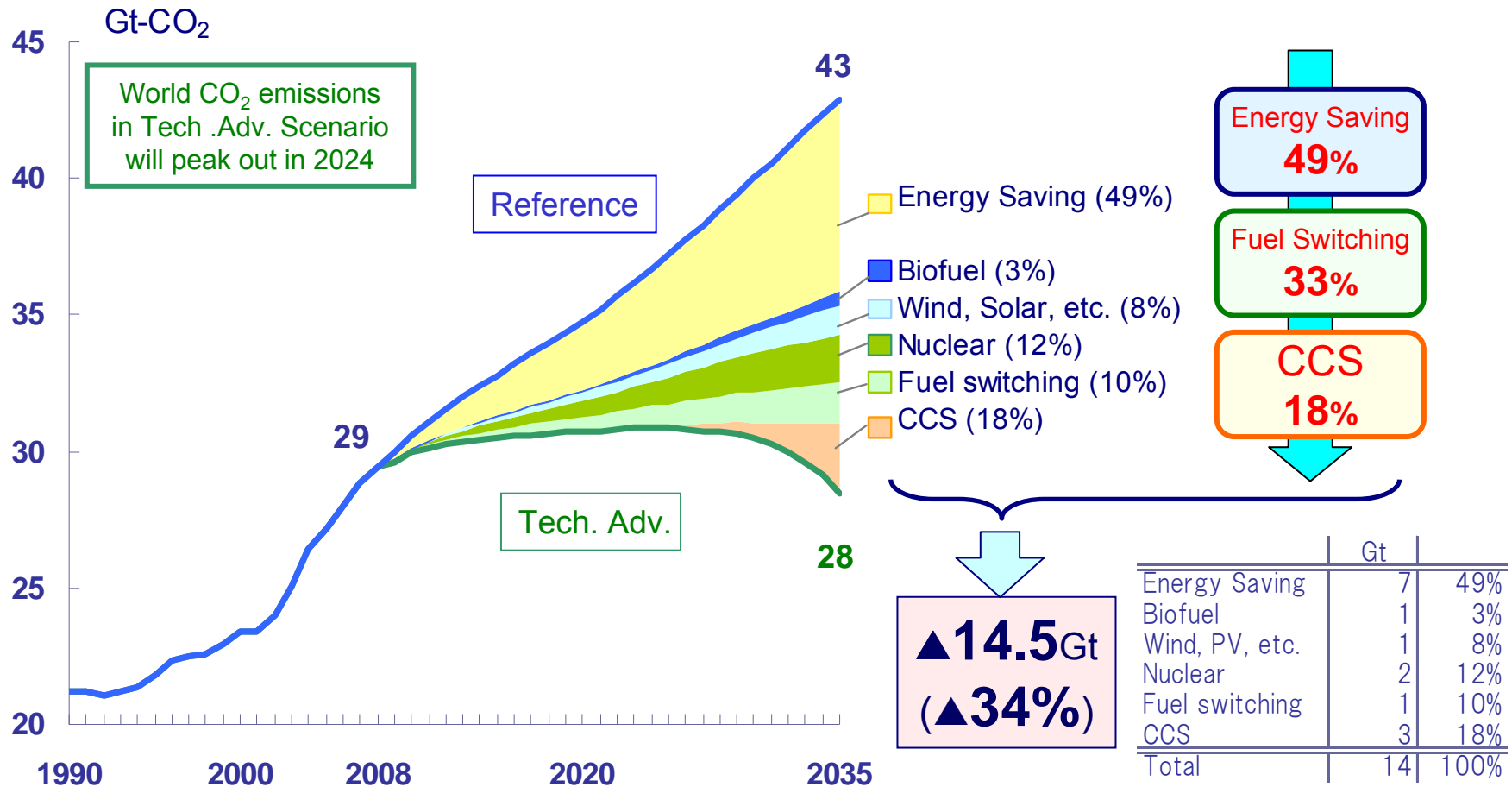
■ India's cumulative CO₂ emissions from 1990 will surpass that of Japan by 2028.

CO₂ Emissions Reduction by Region (World)



- In 2035, Non-OECD's CO₂ emissions reduction (calculated as difference between CO₂ emissions in the Reference Scenario and Tech. Adv. Scenario) is estimated to reach 10.1 Gt, more than doubling that of OECD at 4.4 Gt. Among Non-OECD's projected CO₂ emissions reduction, Asia will account for over 70% in 2035.
- Technology transfer and swift deployment of advanced technology in Asia is indispensable in order to address global warming issues.

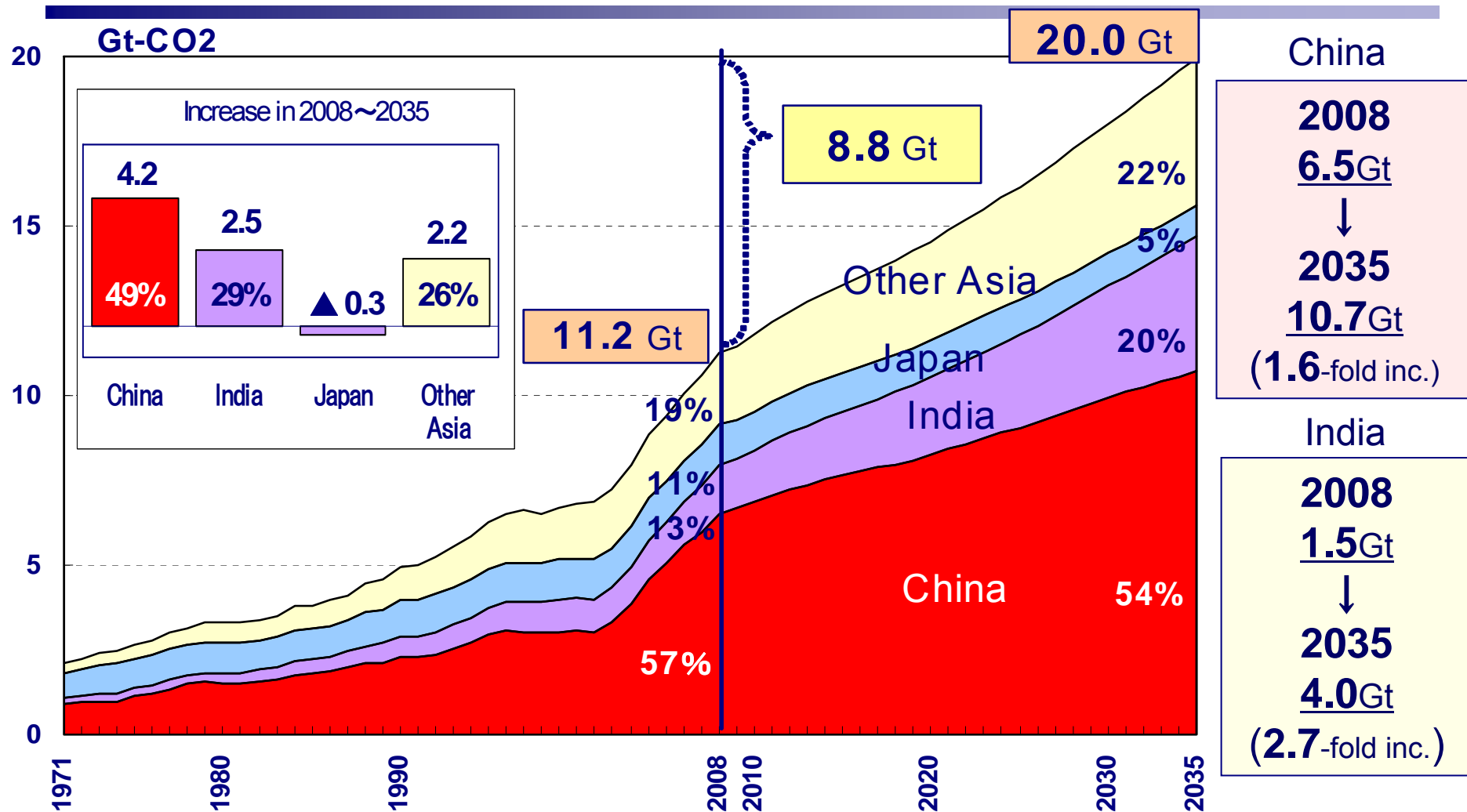
CO₂ Emissions Reduction by Technology (World)



- In the Tech. Adv. Scenario, between 2005 and 2020 the world CO₂ emissions will increase by 3.5 Gt-CO₂ (or 13% up from the 2005 level), while the CO₂ emissions will reach its peak in 2024 with the introduction of advanced energy and environmental technologies.
- Various technological options, including energy saving, enhancement of power generation efficiency, renewables, nuclear, and CCS altogether contribute to massive CO₂ emissions reduction.

CO₂ Emission by Region (Asia)

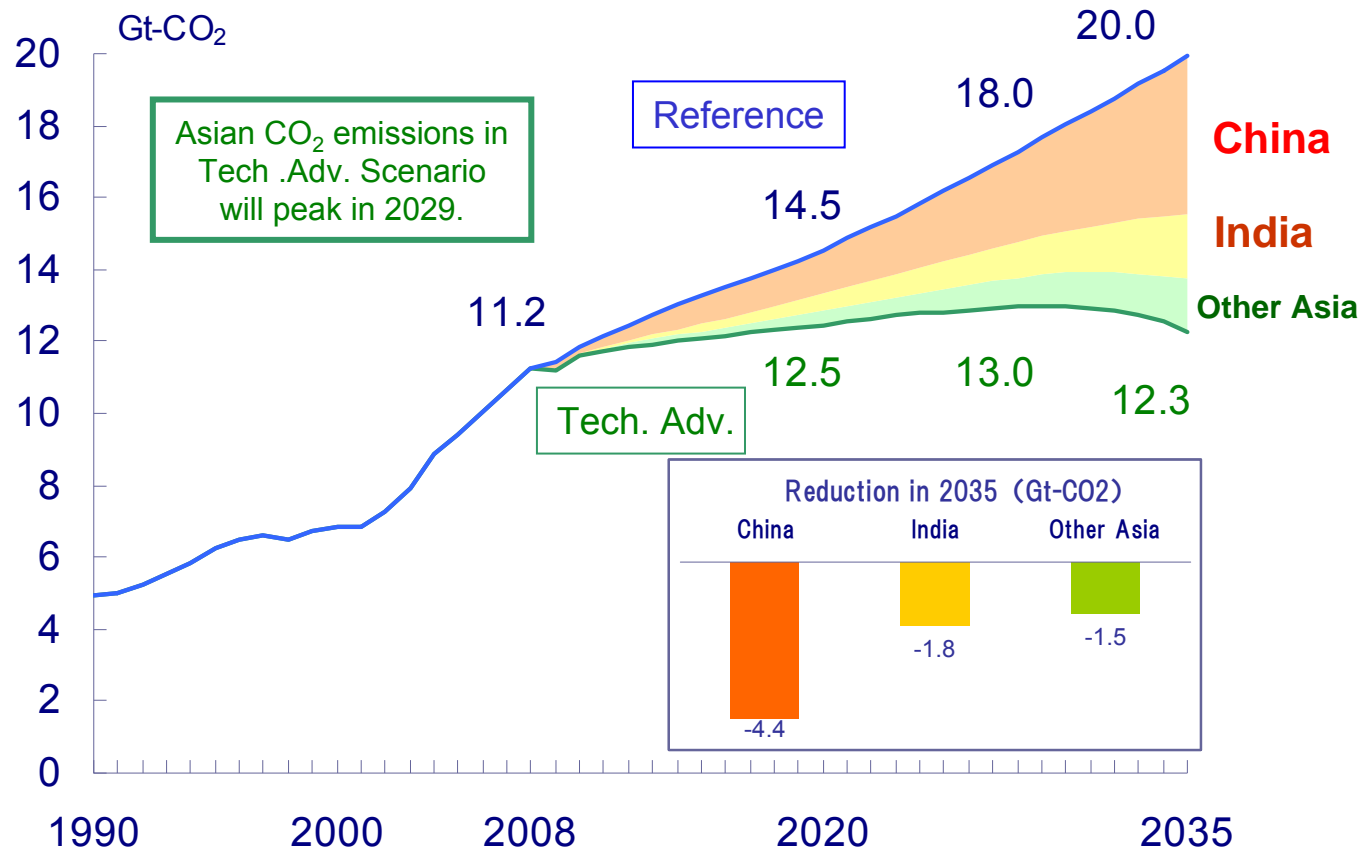
Reference



■ CO₂ emissions of China and India will steadily increase driven by coal consumption, the share accounting for 70% together in Asia in 2035

■ Increase in Asia will account for about 70% of the world CO₂ emissions growth through 2035.

CO₂ Reduction by Region (Asia)



Total **7.7**Gt
(39% reduction)

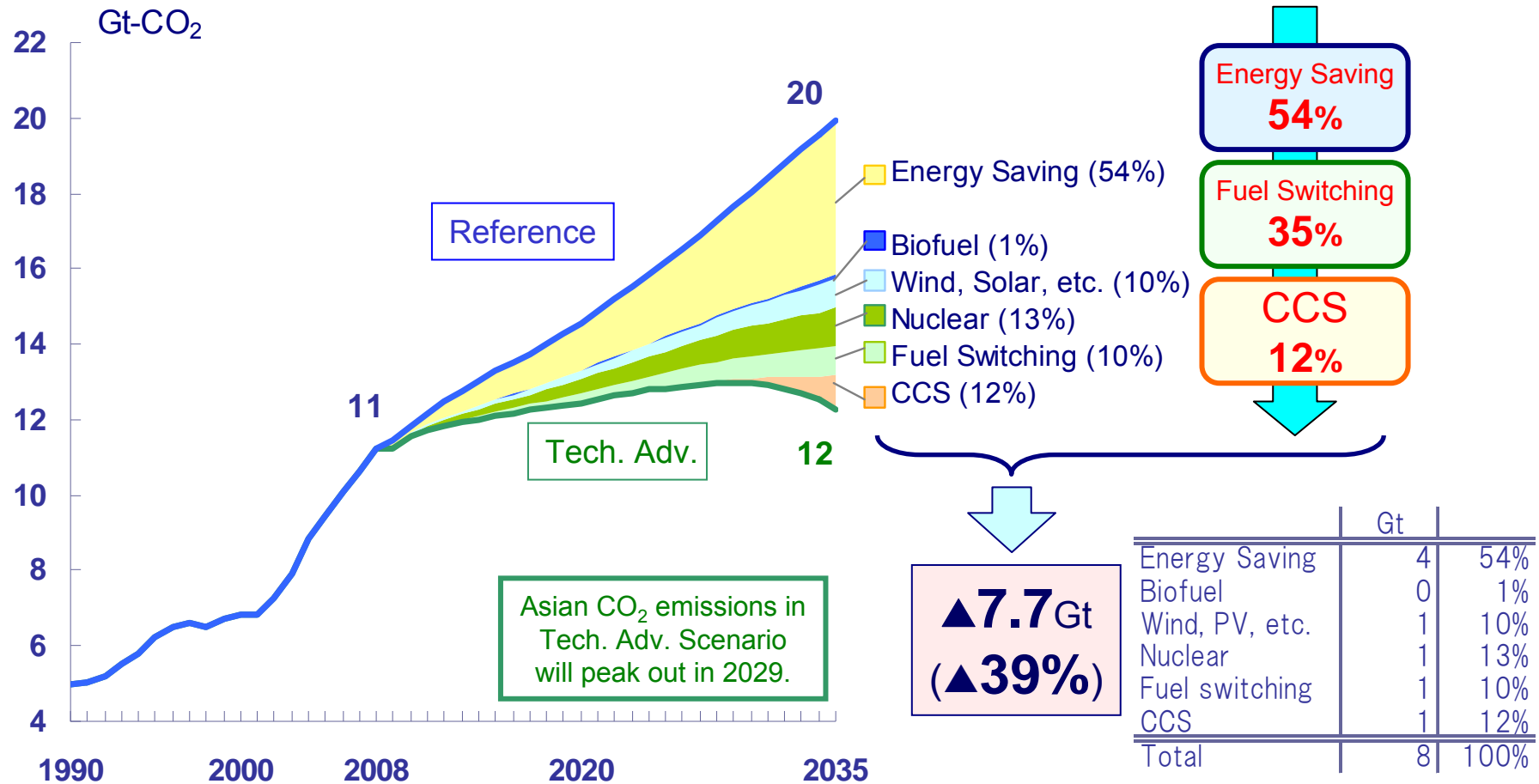
China
4.4 Gt
(57% of total)

India
1.8 Gt
(24% of total)

Other Asia
1.5 Gt
(19% of total)

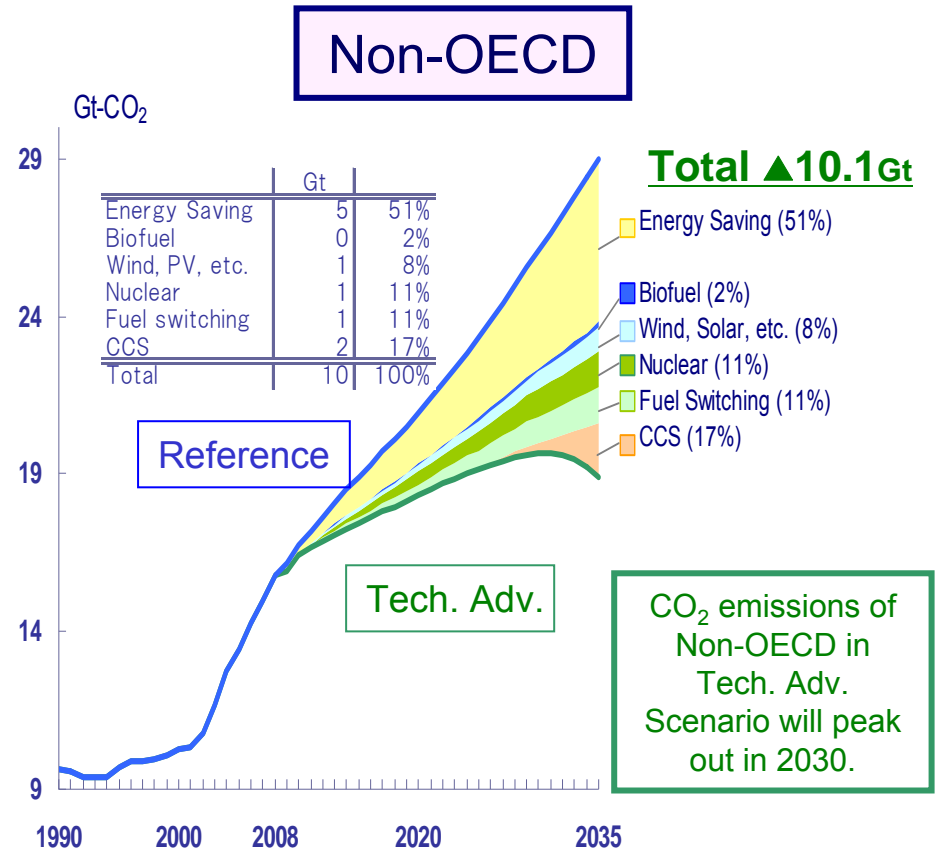
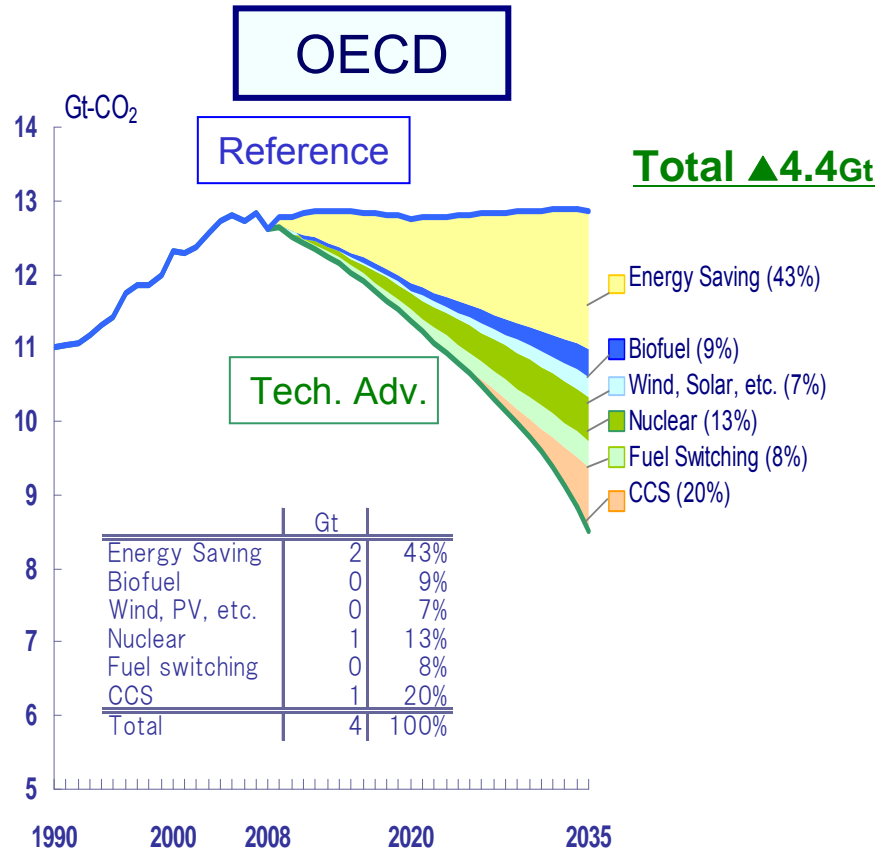
- In the Tech. Adv. Scenario, CO₂ emissions in Asia will reach its peak in 2029, although it will increase by 3.3 Gt-CO₂ (35%) from 2005 to 2025.
- China and India have great potential to reduce CO₂ emissions. China's CO₂ emissions reduction (calculated as difference between CO₂ emissions in the Reference Scenario and the Tech. Adv. Scenario) will account for 60% of Asia's reduction in 2035. India and other Asian countries will account for the remaining 40%.

CO₂ Emissions Reduction by Technology (Asia)



■ Aggressive development and deployment of advanced technologies in Asia enables to considerably reduce CO₂ emissions and realize its peak-out by 2030.

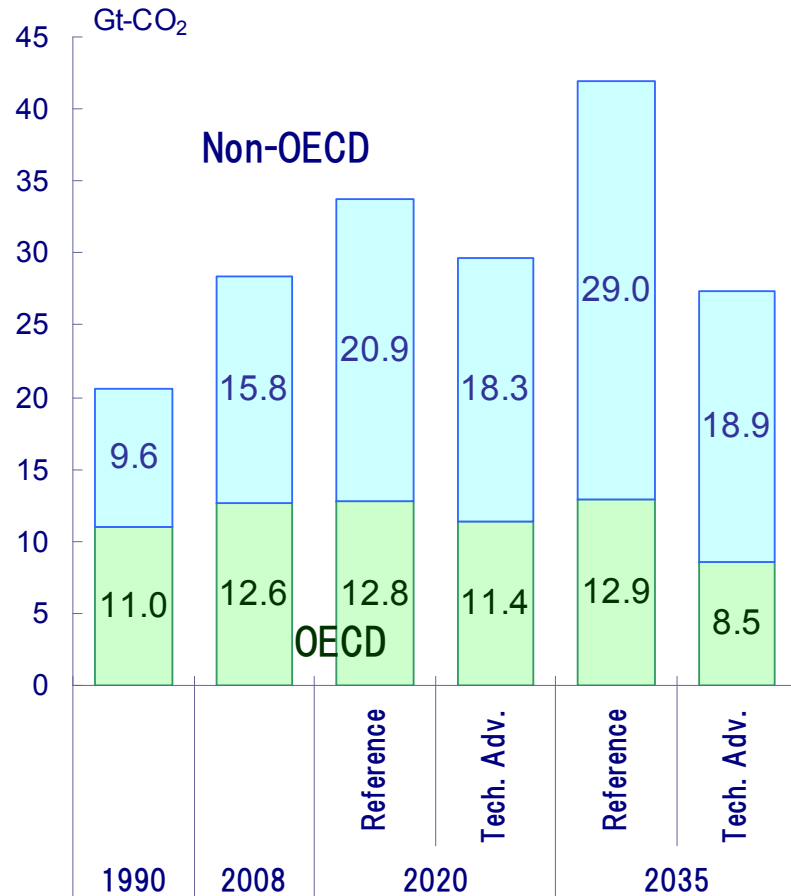
CO₂ Emissions Reduction by Technology (OECD, and Non-OECD)



■ Various technologies need to be introduced to reduce CO₂ emissions. In OECD, of the total CO₂ emissions reduction of 4.4 Gt, energy saving will be responsible for the largest at 43% (or 1.9 Gt), nuclear 13% (or 0.6 Gt), renewable energy 16% (or 0.7 Gt), fuel switching 8% (0.4 Gt), and CCS 20% (0.9 Gt).

■ In Non-OECD, of the total CO₂ emissions reduction of 10.1 Gt, energy saving will be responsible for the largest at 51% (5.2 Gt). Supportive measures concerning technology transfer and establishment of efficiency standards is important to realize potential for CO₂ emissions reduction as well as to enhance energy security

CO₂ Emissions Reduction in 2020 (OECD, and Non-OECD)



CO₂ growth rate (relative to 1990)

	2020	
	Reference	Tech. Adv.
World	+ 64%	+ 45%
OECD	+ 16%	+ 3%
Non-OECD	+ 118%	+ 91%
	2035	
	Reference	Tech. Adv.
World	+ 102%	+ 34%
OECD	+ 17%	▲23%
Non-OECD	+ 202%	+ 97%

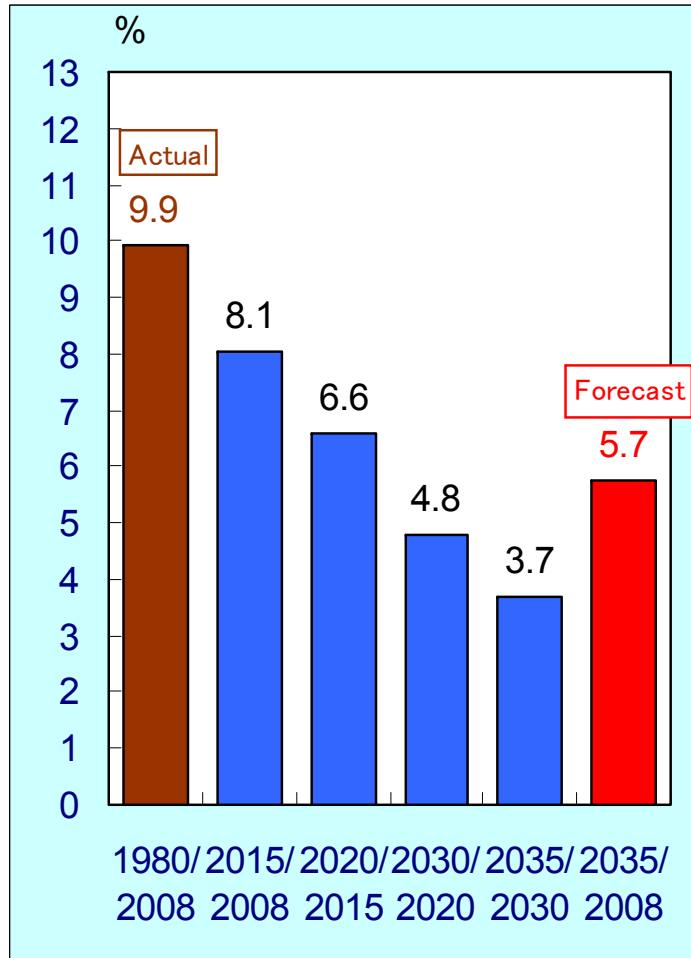
*Include CO₂ emissions from bunker fuel demand

- In 2020 (the target year of post-Kyoto protocol), OECD's CO₂ emissions will increase by 0.2 Gt-CO₂ from 2008 (1% increase) and that of Non-OECD will increase by 5.1 Gt-CO₂ from 2008 (33% increase or 35 times as large as OECD). This suggests that urgent measures be taken to reduce CO₂ emissions in Non-OECD.
- In the Tech. Adv. Scenario, OECD's CO₂ emissions will increase by 3% from 1990 to 2020, while it will decline by 23% in 2035 from 1990. Non-OECD's CO₂ emissions will be 91% larger in 2020 from 1990 and 97% larger in 2035 from 1990.

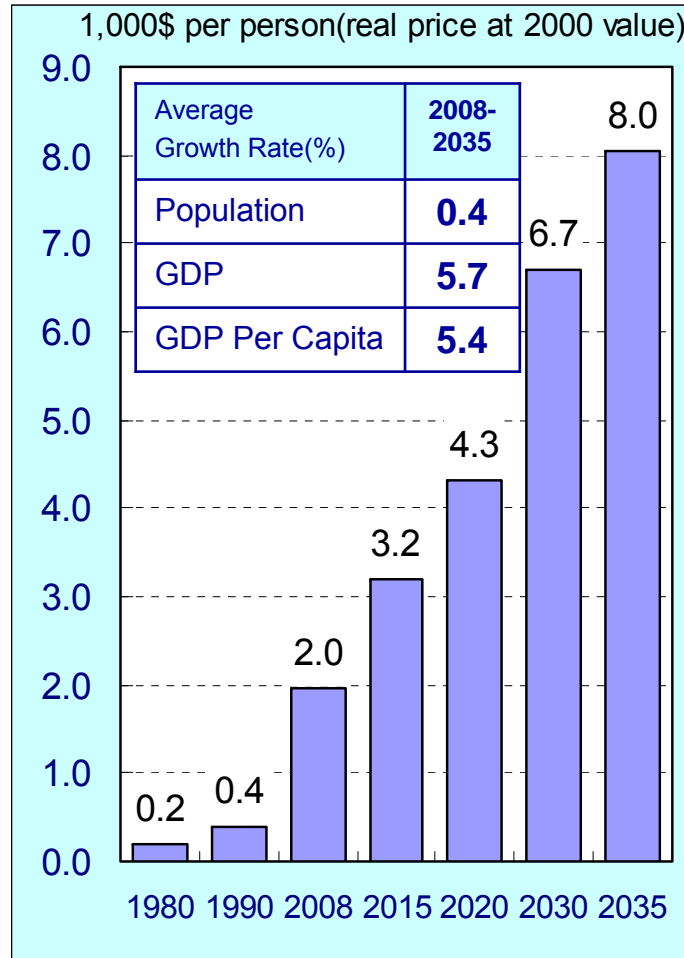
Energy Demand and Supply in China

GDP Growth of China

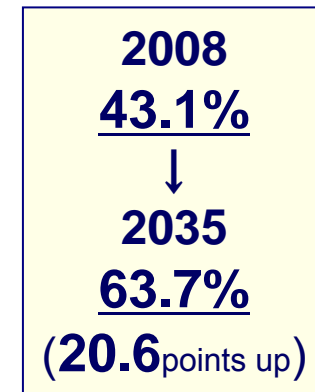
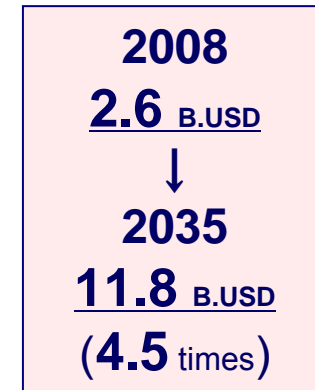
【 GDP Growth Rate 】



【 GDP Per Capita 】



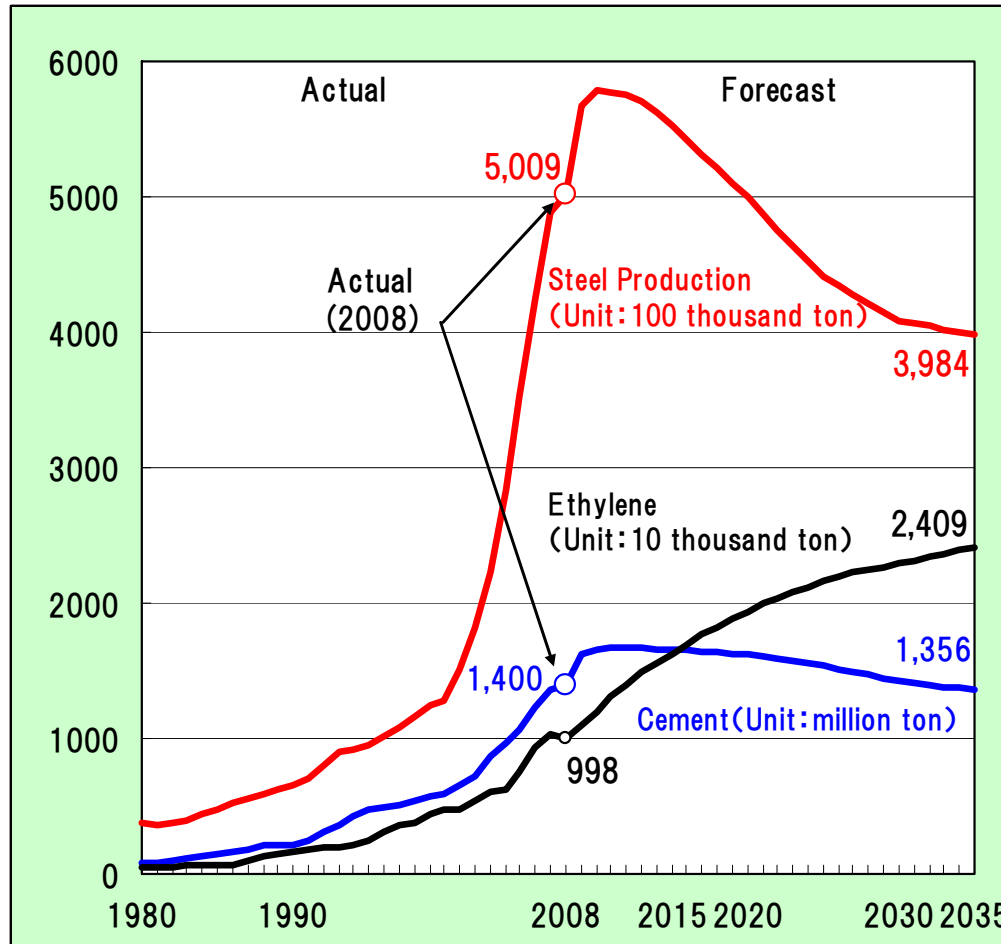
GDP



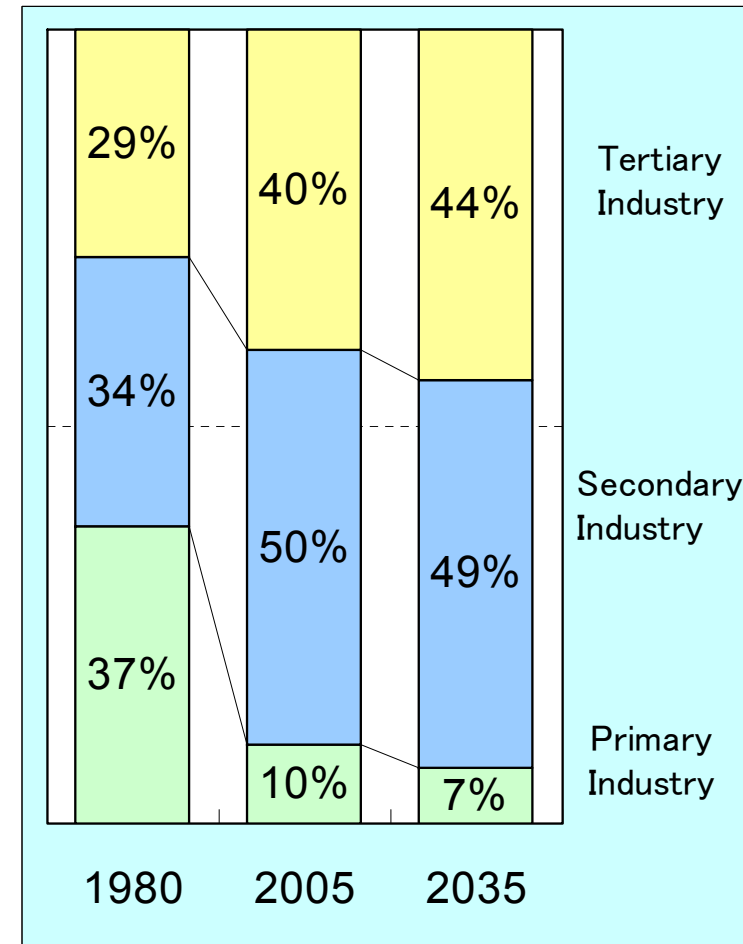
- In the future, China's economy will gradually grow at a moderate pace due to the shift from export and investment-driven growth to domestic consumption-led growth. Other factors, including decrease in labor, environmental considerations and resource constraints, are additional reasons for the moderate growth.
- GDP per capita (at 2005 price) is expected to reach 8 thousand USD in 2035, a four-fold increase from the 2008 level.

Raw Material Production and Industrial Structure in China

【 Raw Material Production 】

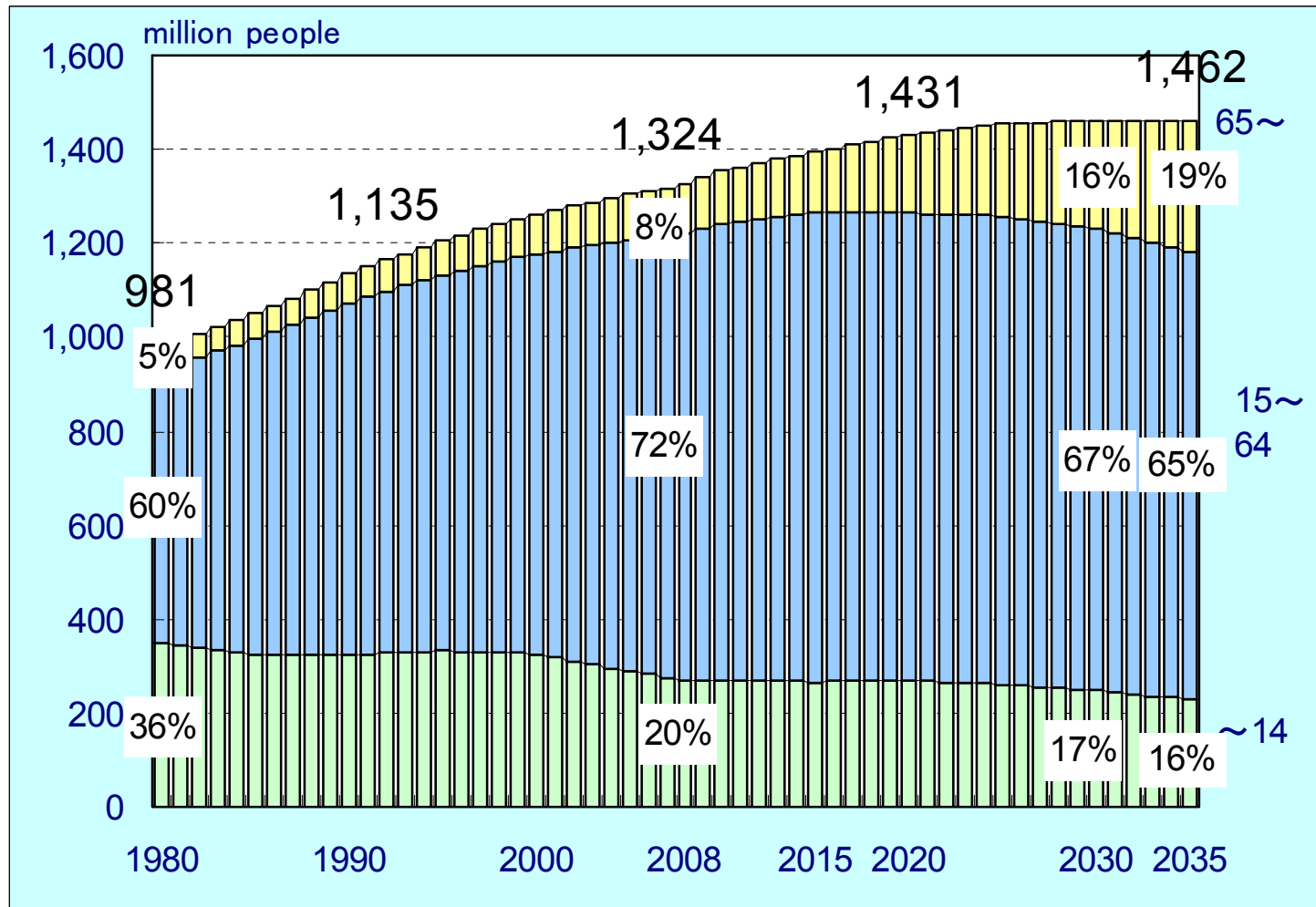


【 Industrial Structure 】



- Raw materials production will reach peak in the future. Steel production will decrease from about 500 million ton currently to below 400 million ton by 2035.
- Heavy industry is likely to decrease while the weight of secondary industry will remain at the same level by 2035.

Population in China



Average Growth Rate (%)	2008-2035
Total	0.4
Over 65	3.7

Total Population (Million)

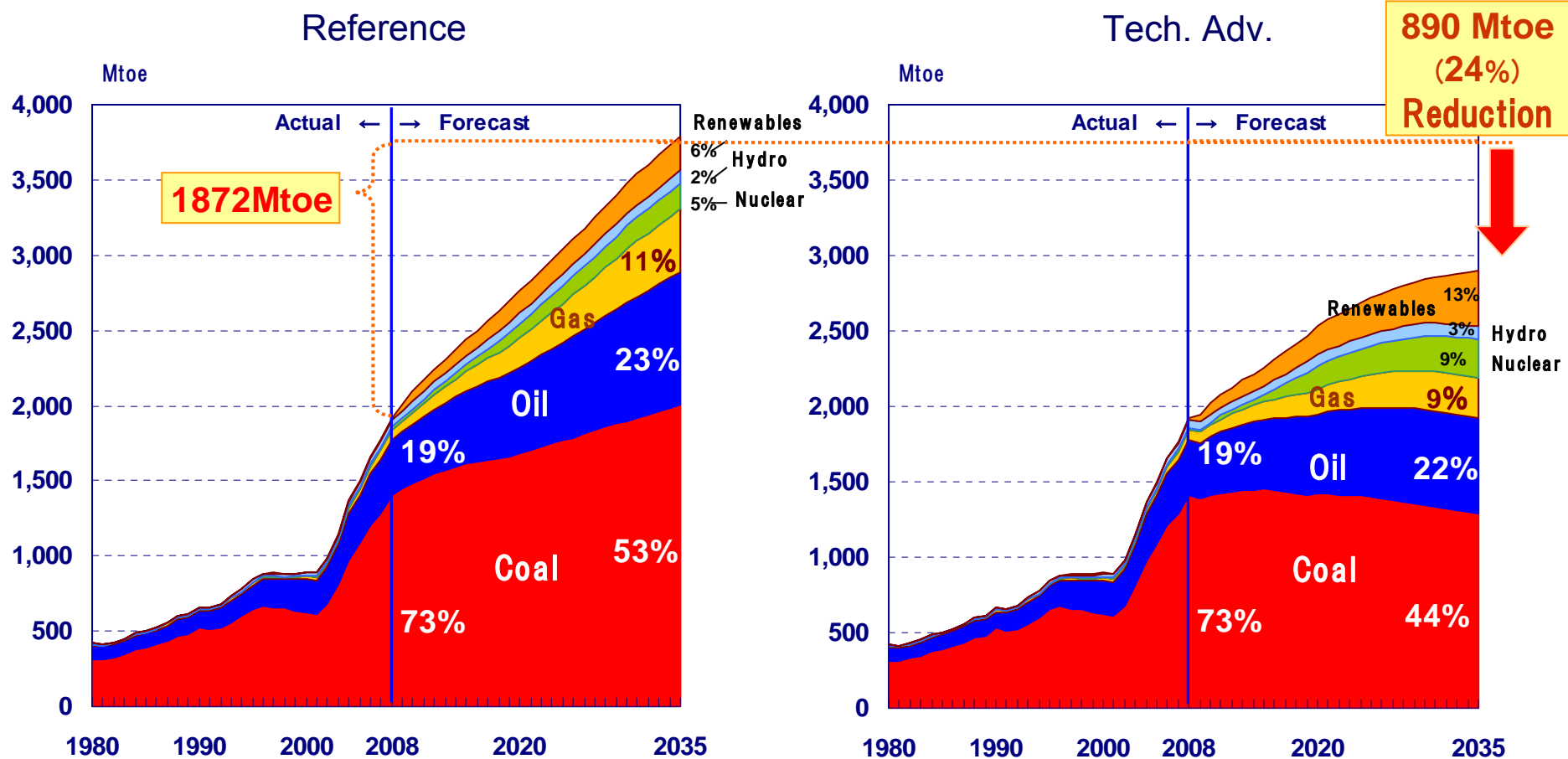
2008
1,320
 ↓
2035
1,460
 (1.1 times)

Urbanization Rate

2008
43.1%
 ↓
2035
63.7%
 (20.6 points up)

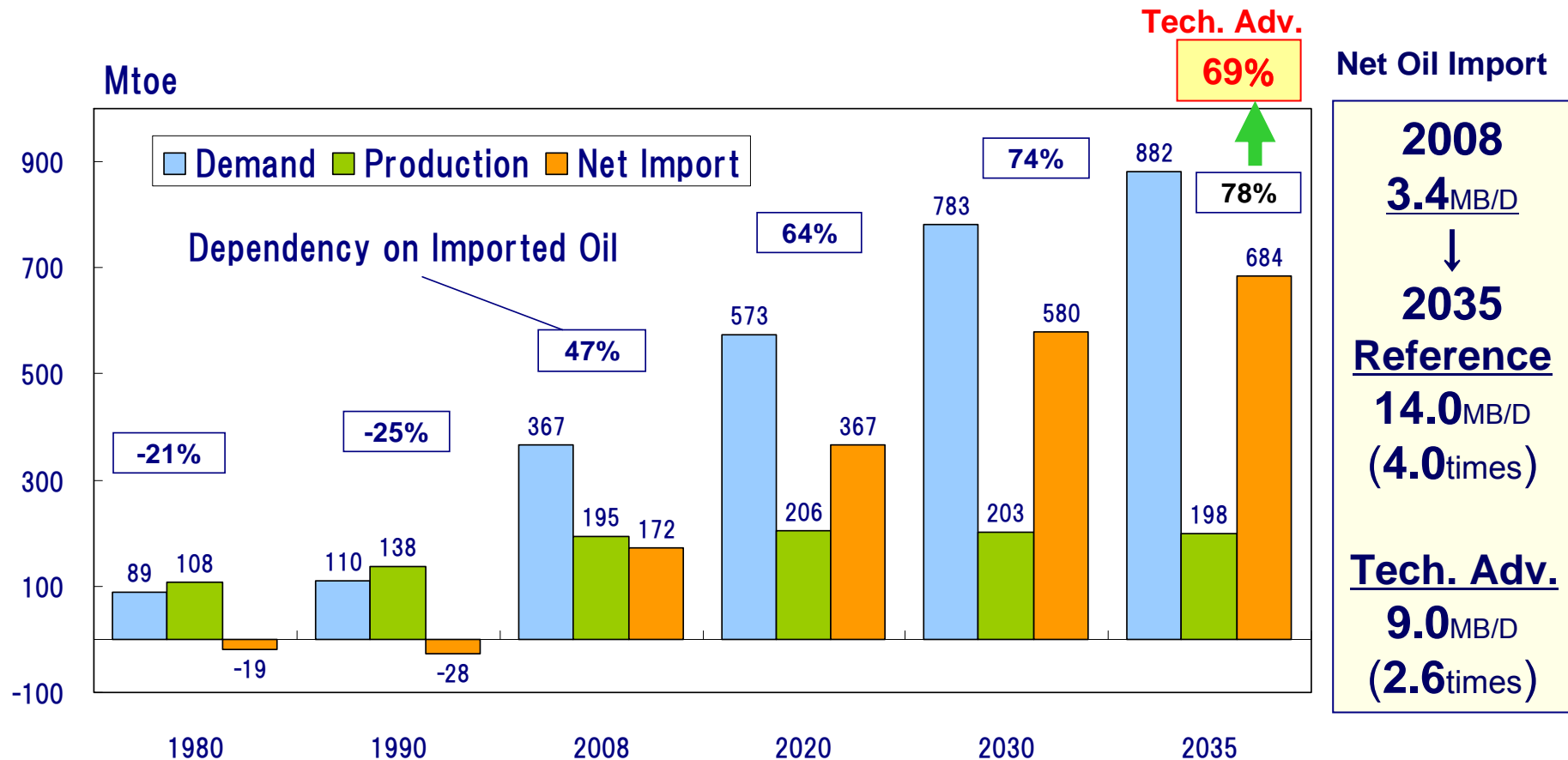
- Population will increase at 0.4% annually and will peak at around 1,460 million by 2030 and will be surpassed by India.
- The share of population over 65 will reach 19.2% in 2035 from 8% in 2008. Labor force population will peak by 2015 and begin to decrease.

Primary Energy Demand in China



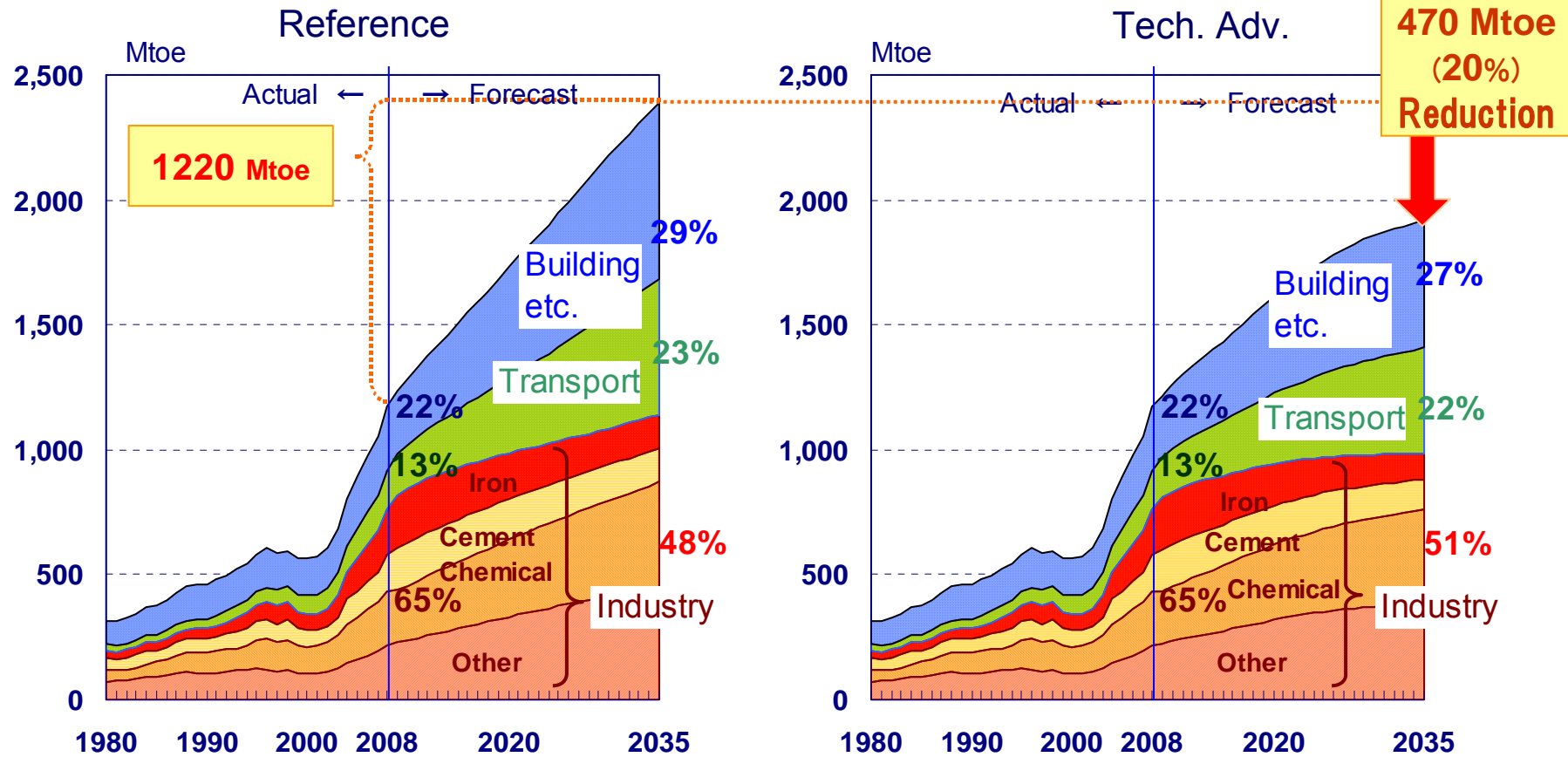
- TPED will increase at an annual rate of 2.5% in the Reference Scenario at the back of robust economic growth. Coal will grow substantially driven by the power sector, and oil will expand reflecting rapid motorization. Natural gas will increase sharply for the household and commercial usage, especially in urban areas.
- In the Tech. Adv. Scenario, coal demand will decrease, especially in power generation, accounting for 890 Mtoe (24% down) reduction compared with Reference Scenario in 2035.

Oil Demand and Supply in China



- Net oil import is projected to expand from 170 million ton (3.4 mb/d) in 2008 to 684 million ton (14.8 mb/d) in 2035. As a result, net oil import ratio will reach 78% in 2035 from 47% in 2008.
- In the Tech. Adv. Scenario, oil demand will grow at a relatively slow rate, but net oil import ratio will still increase to 69% in 2035.
- Continued investment needs to be made to explore/develop oil fields in the western part of China and offshore in order to sustain domestic oil production.

Final Energy Demand in China

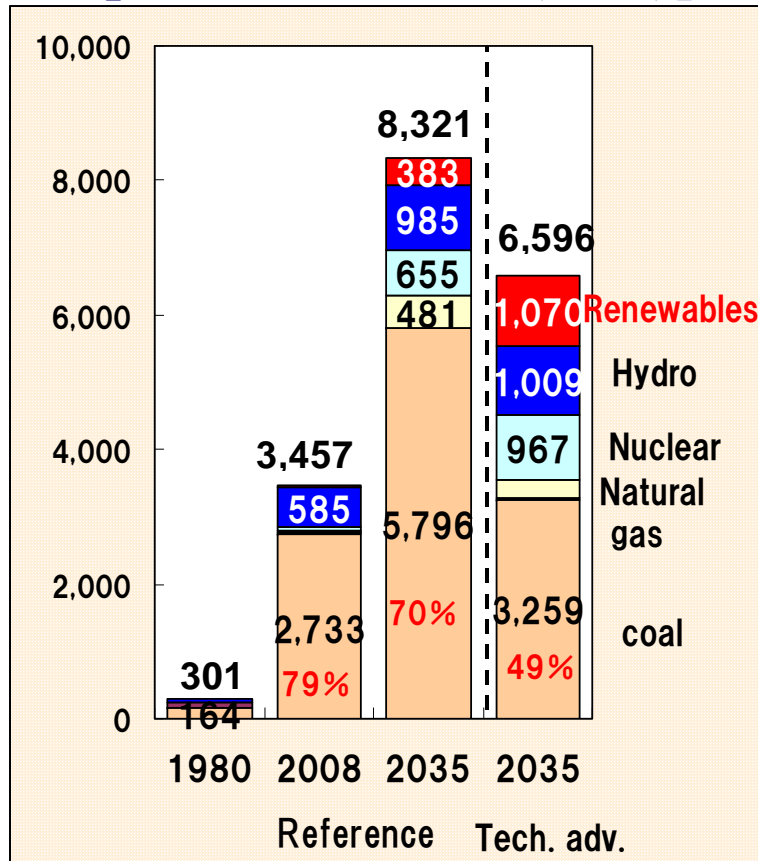


Note: industrial including non-energy usage.

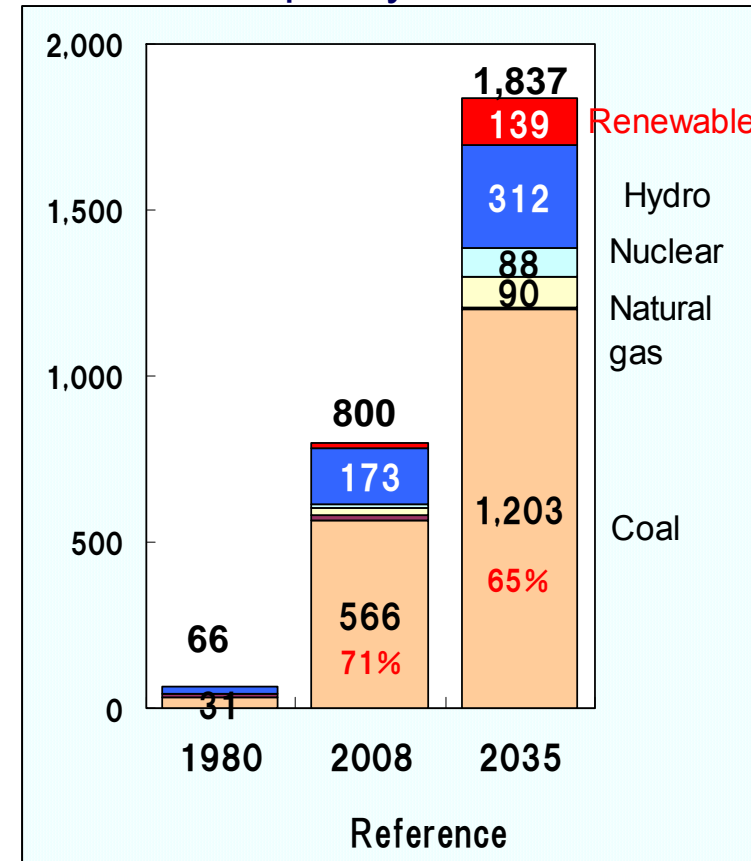
- Energy demand of heavy industry will grow relatively slowly in the future as a result of the sluggish growth of raw material production.
- By contrast, energy demand of the household, building, and transport sectors will increase substantially. Particularly, the share of household and building sectors will reach 29% in 2035 (from 22% in 2008) although per capita energy demand of the household and commercial sectors will still be lower than international average.
- In the Tech. adv. Scenario, energy demand of the household, building, and transport sectors is expected to continue growing.

Power Generation Sector

【Power Generation (TWh)】

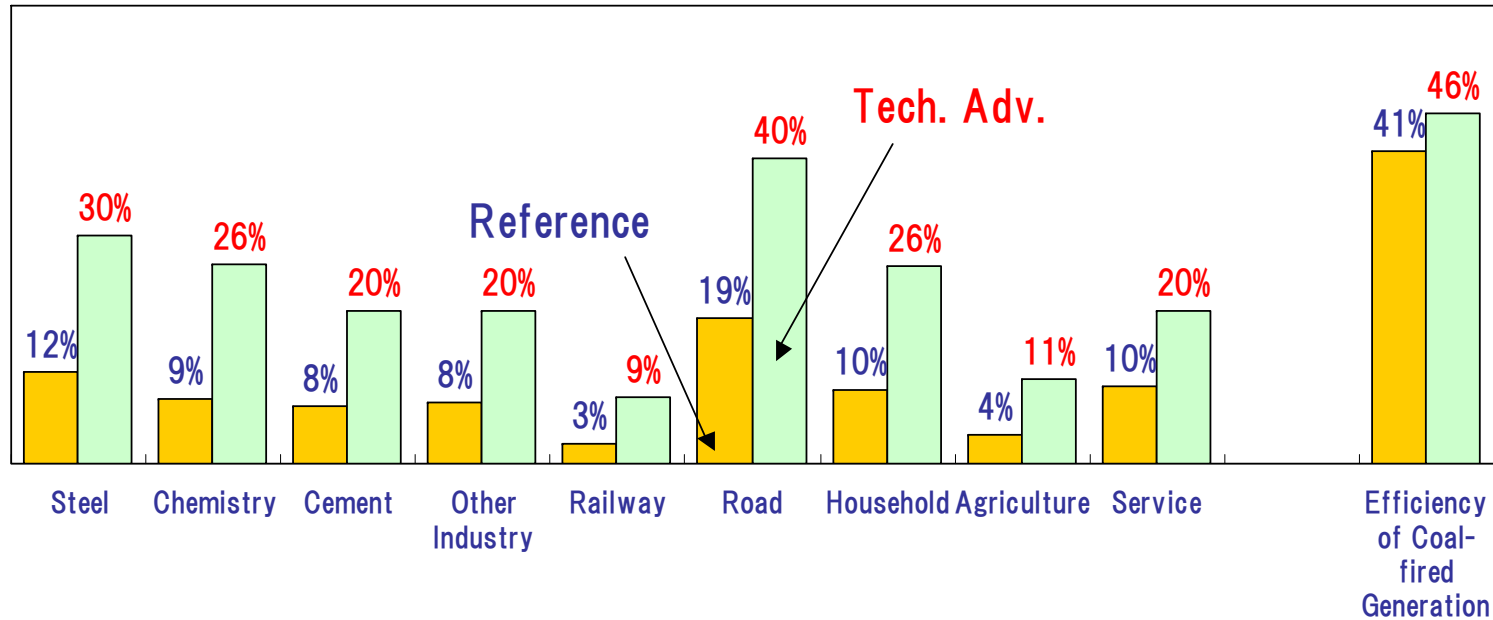


【Capacity (GW)】



- Total power generation capacity will increase from 800 GW in 2008 to 1,800 GW in 2035, showing average annual capacity growth of 38 GW. The share of coal-fired power plant will gradually decline to 65% in 2035.
- Total power generation will increase from 3.5 TWh in 2008 to 8.3 TWh in 2035. The share of coal-fired will decline from 79% in 2008 to 70% in 2035. Power generation from gas-fired, nuclear and renewables will substantially increase, while hydro power will represent moderate growth.
- Coal-fired power capacity will reach 1,203 GW in 2035 representing almost half of the world coal-fired power generation capacity.
- In the Tech. Adv. Scenario, generation from nuclear, hydro and renewable energy will sharply expand to substitute a decline in coal-fired generation.

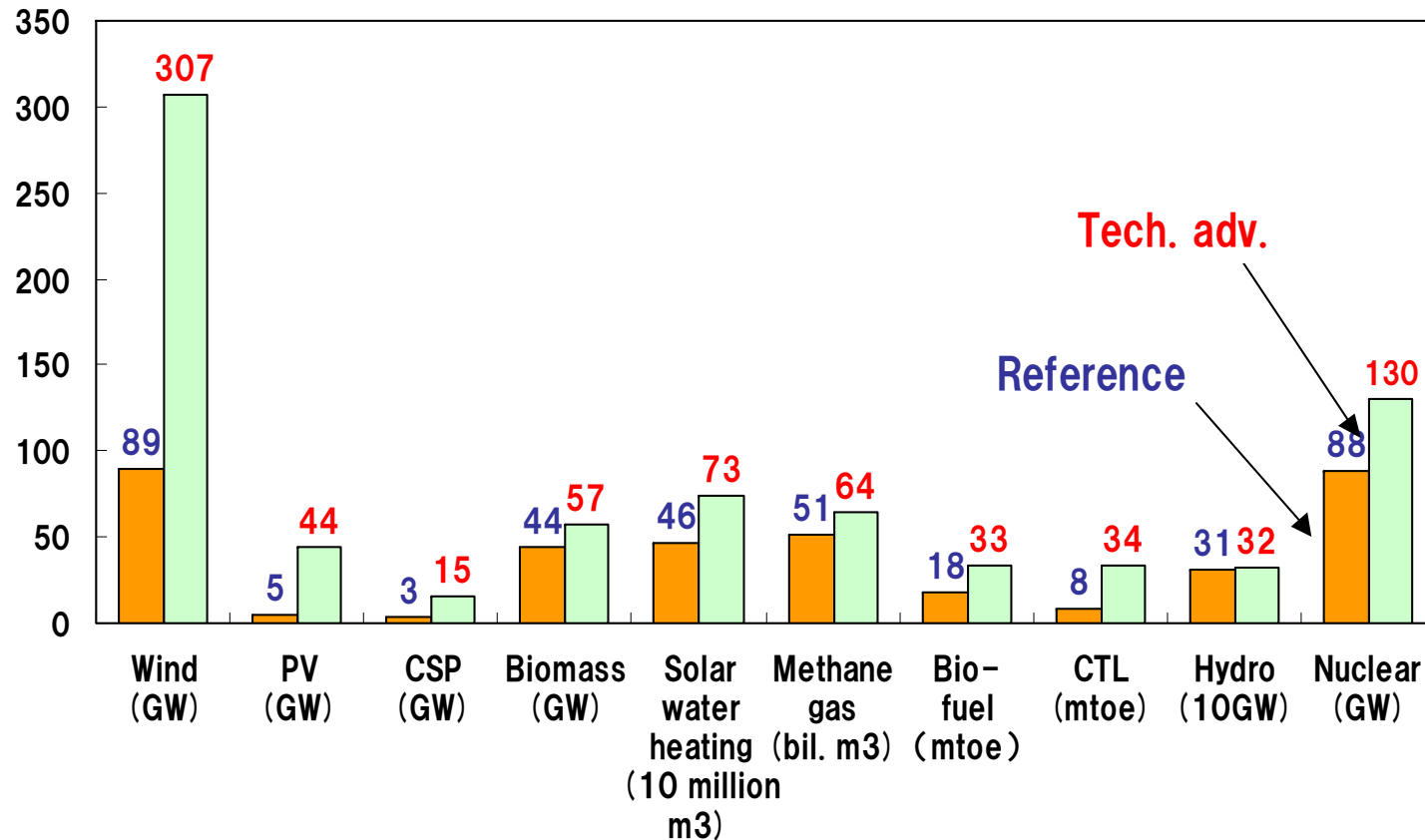
Energy Savings by Sector



Energy saving ratio in 2035 from 2005

- In the household and building sectors, heating price reform and energy labeling system will play key roles for energy efficiency improvement.
- The chemical sector may need to introduce large-scale production facilities toward improving production process efficiency in addition to the fuel switching from coal to alternative energy sources.
- The cement industry would have to increase dry-kiln system (from 50%→nearly 100%) and expand waste heat recovery system.
- In the power sector, expanding average power generation capacity (60MW→ 350MW) and introduce advanced technology like IGCC will provide considerable savings of coal demand.

Non-fossil Fuel Outlook in China (2035)



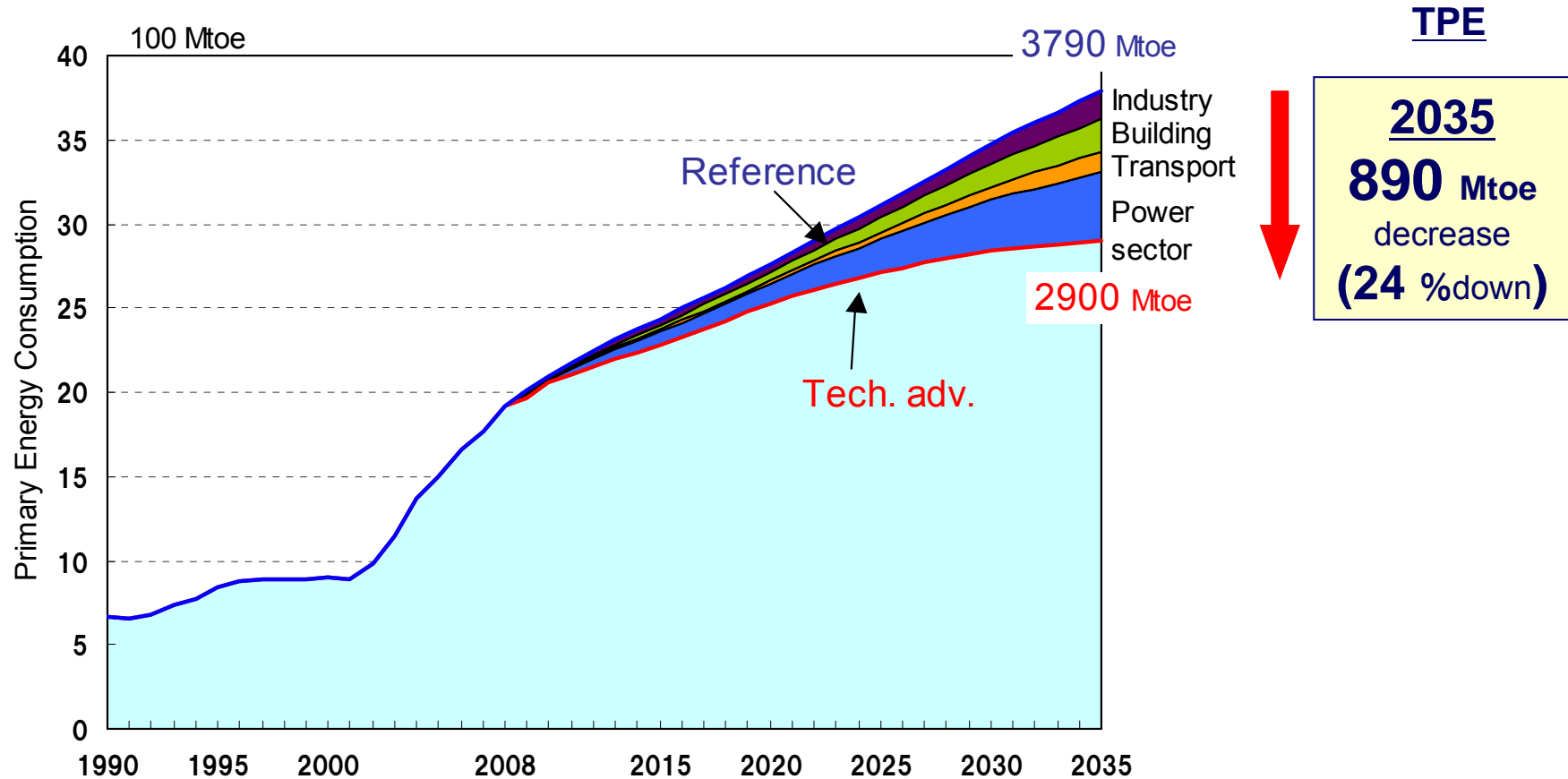
Non-fossil Fuel (2035)

Reference
490 Mtoe
 Ratio of TPE
(13%)

Tech. Adv
710 Mtoe
 Ratio of TPE
(24%)

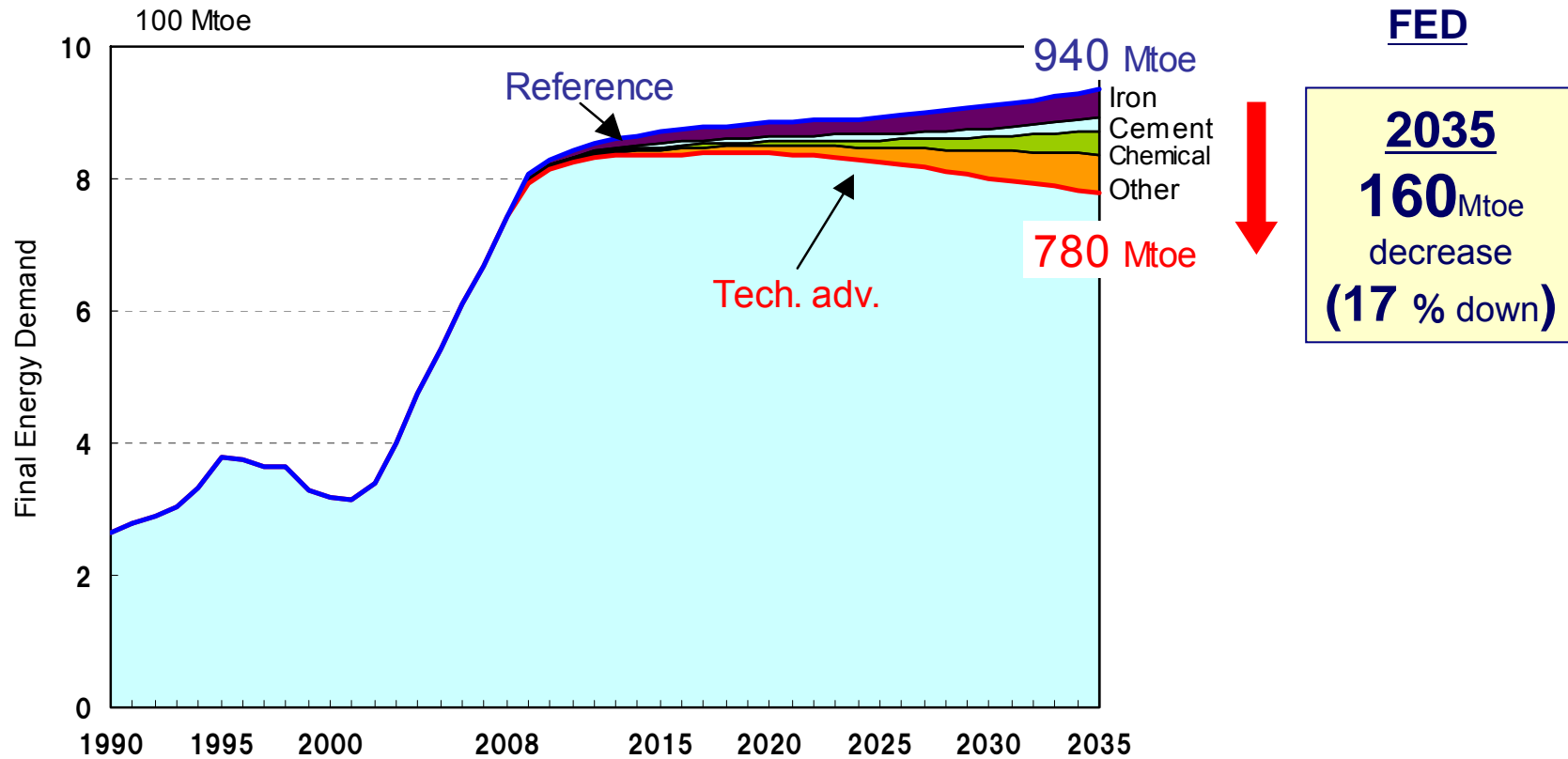
- Hydro expansion will be limited due to resource constraints and environmental considerations.
- Great expansion of nuclear and wind power is expected to meet considerable electricity demand growth and need for environment protection.
- Non-fossil fuel will reach 490 Mtoe in 2035, representing 13% of TPED in the Reference Scenario. In the Tech. Adv. Scenario, the share of non-fossil fuel will represent a higher share at 24% by 2035.

Primary Energy Demand in China



- In the Tech. Adv. Scenario, TPED will be 890 Mtoe lower (or 24%) compared with the Reference Scenario. The power sector will have the largest potential for energy savings.

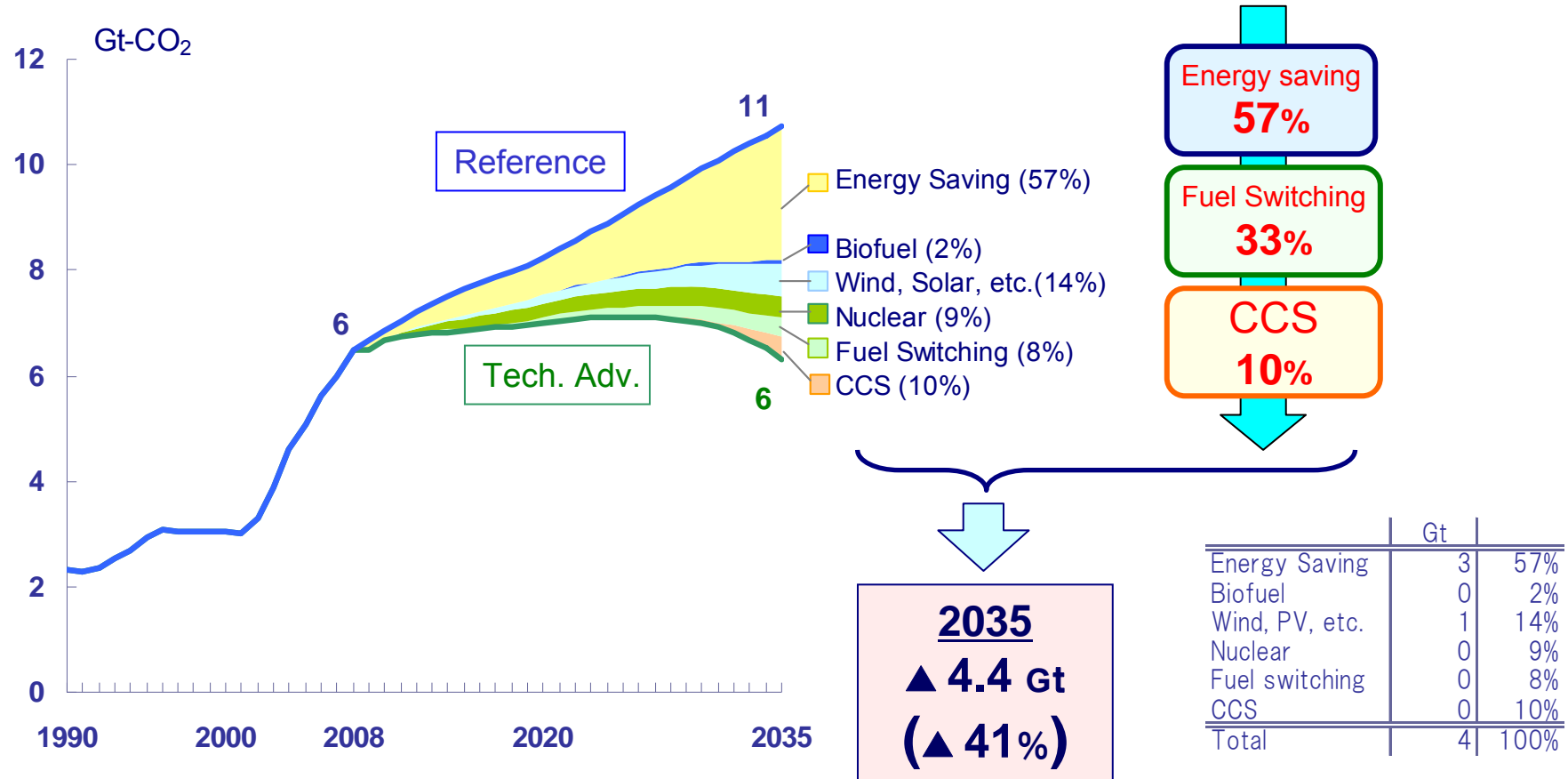
Final Energy Demand in the Industry Sector



Note: Include energy demand in coke-production process

- In the Reference Scenario, energy demand of the industry sector will grow moderately at 0.6% per year after 2020, reflecting on energy saving and decreasing trend of raw material production.
- In the Tech. Adv. Scenario, final energy demand will decrease by 160 Mtoe (17%) in the industry sector compared with Reference Scenario in 2035.

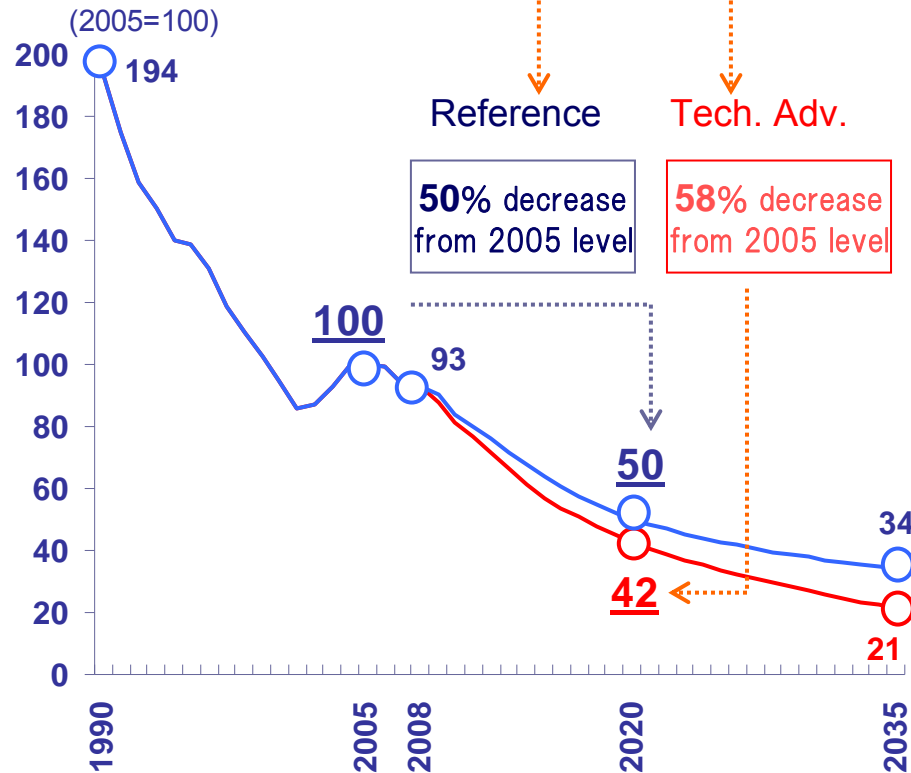
CO₂ Emissions in China



- In the Reference Scenario, CO₂ emissions will increase by 4.2 Gt (up 65%) between 2008 to 2035.
- In the Tech. Adv. Scenario, CO₂ emissions will be 4.4 Gt (down 41%) lower than the Reference Scenario in 2035.
- CO₂ emissions will peak around 2025 due to energy saving and fuel switching to non-fossil fuels.

CO₂ Emissions per GDP

National Target : 40 to 45% reduction by 2020



Decomposition Analysis of CO₂ Emissions

	1990-2005	2005-2020	
		Reference	Tech. adv.
CO ₂ Emission ΔC	5.4	3.3	2.2
Carbon Intensity Δ(C/E)	▲ 0.2	▲ 0.8	▲ 1.3
Energy Saving Δ(E/Y)	▲ 4.1	▲ 3.7	▲ 4.3
Economic Growth ΔY	10.1	8.2	

$$C = (C/E) * (E/Y) * Y$$

$$\Delta C = \Delta (C/E) + \Delta (E/Y) + \Delta Y$$

Decarbonization / Energy-Saving / Economic-Growth

- In November 25, 2009, the State Council of the Chinese government decided to improve CO₂ intensity (calculated as CO₂ emissions per GDP) by 40%-45% from the 2005 level by 2020.
- Towards 2020, CO₂ emissions per GDP is projected to decrease by 50% in the Reference Scenario, and by 58% in the Tech. Adv. Scenario. Even in the Reference Scenario, the projected CO₂ emissions per GDP will substantially improve beyond the official target level in 2020.

Energy Demand and Supply in India

Energy and Economic Situation in India

Robust economic growth and consequent energy demand growth

Annual Average Growth Rate (AAGR) from 1990 to 2008

GDP: 6.3%, TPES: 5.1%, Coal: 5.1%, Oil: 4.9%, Gas: 7.0%

Rapid increase in CO₂ emissions and serious local environmental problems

AAGR from 1990 to 2008: 5.1%

Electric power shortage

Energy efficiency improvement

TPES per GDP (2008) (toe per million \$ at 2000 value)

India: 561, World: 280, Non-OECD: 561, Japan: 96, China: 742

Rising trend of reliance on imported oil

Dependency on oil import (2008): 73%

Heavy reliance on coal

Share of coal on TPES: 57% (2008)

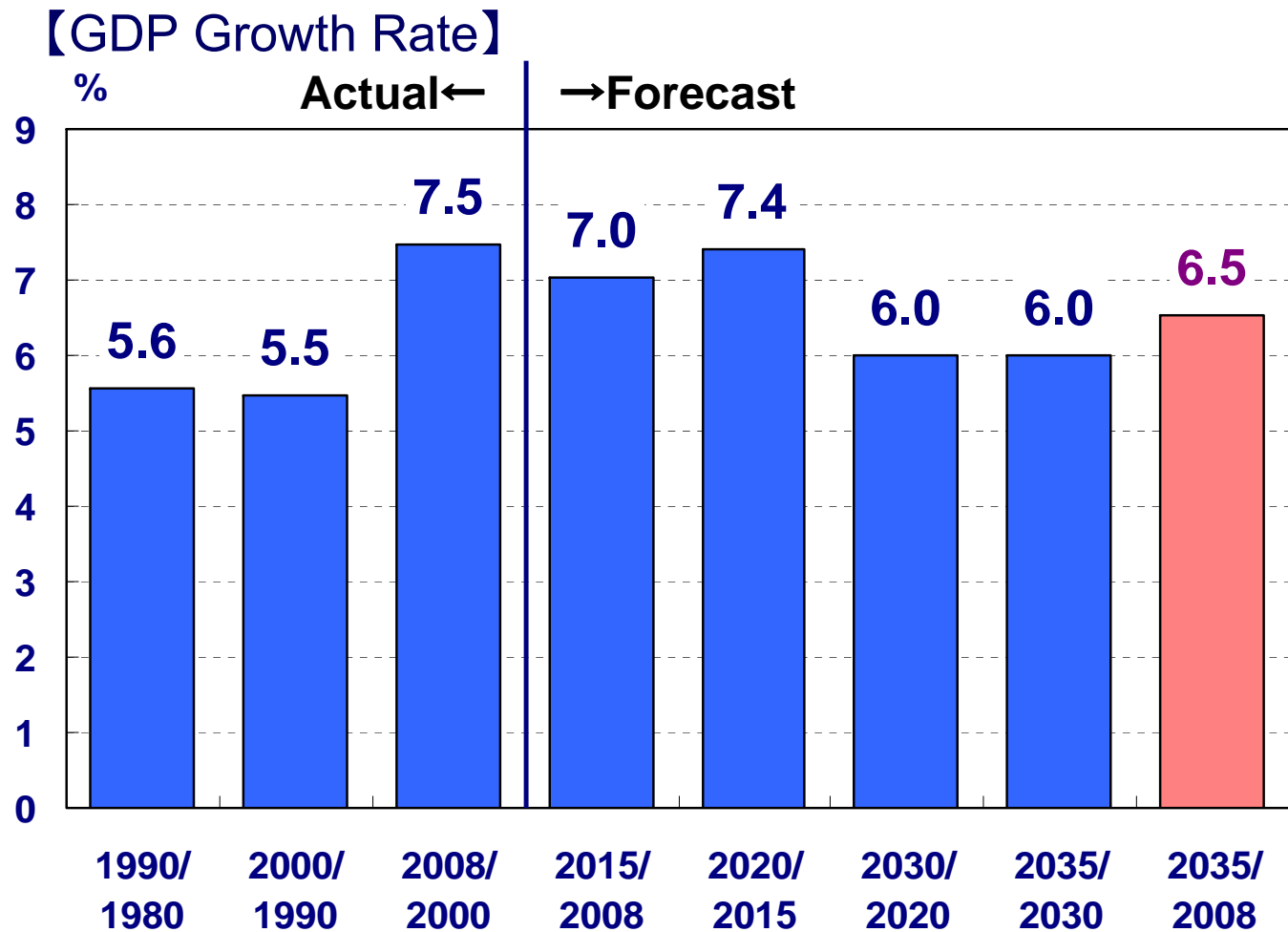
Energy Policy of India

Basic Agenda of Energy Policy on 11th 5 year Plan (2007/08~2011/12)

(1) Encouragement of electric power production and reform of the electricity transmission sector, (2) Expansion of domestic coal production and infrastructure served for coal import, (3) Promotion of exploration and acquiring of foreign equity, (4) Energy sector reform and deregulation, (5) Energy efficiency improvement, (6) R&D, (7) Environmental protection, (8)

Comprehensive approach for dealing with energy and environmental issues

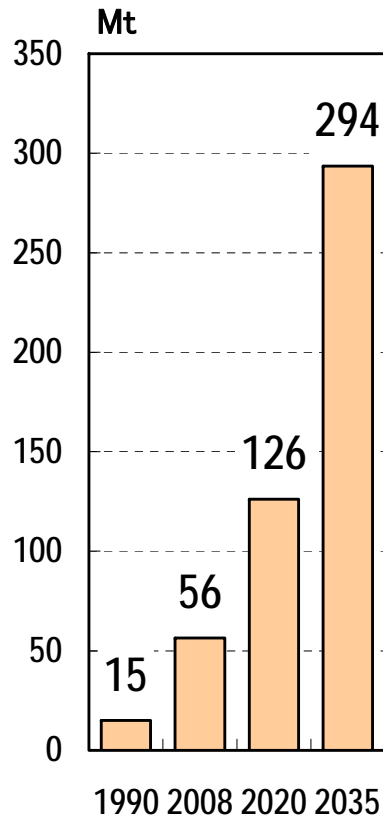
GDP Growth



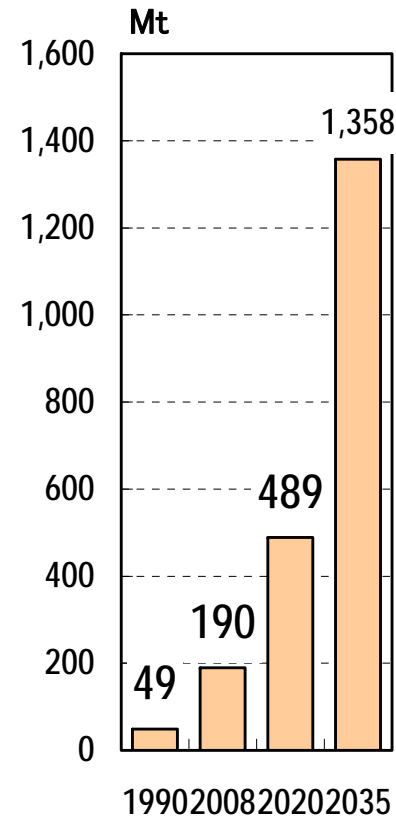
- GDP will continue to grow robustly due to increase in workforce population, improved quality of labor force, opening up of the market, and growing FDI.
- Downside factor on GDP growth is the shortage of infrastructure in electric power supply, transportation, port and railway.
- In 2035, GDP per capita will increase to reach 3,000 USD, one-third of that of China.

Production of Raw Material in India

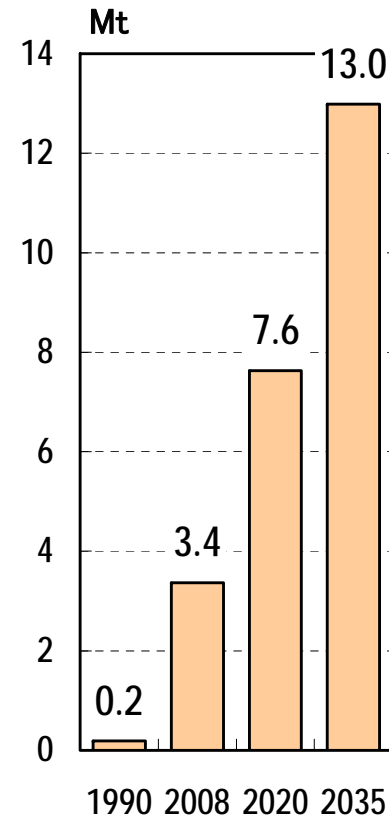
【Crude Steel】



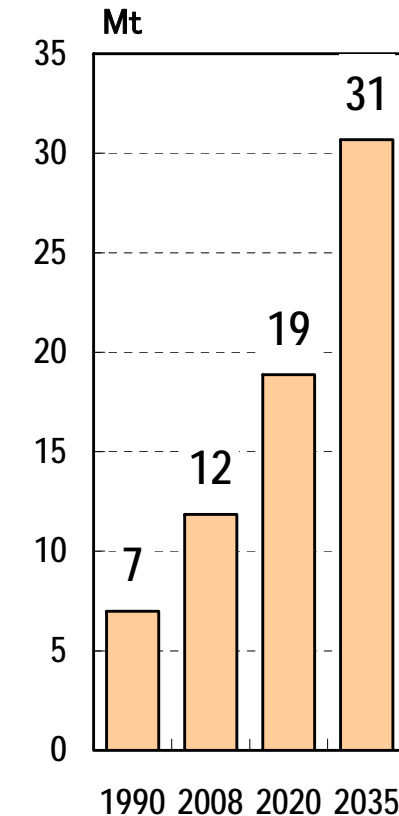
【Cement】



【Ethylene】

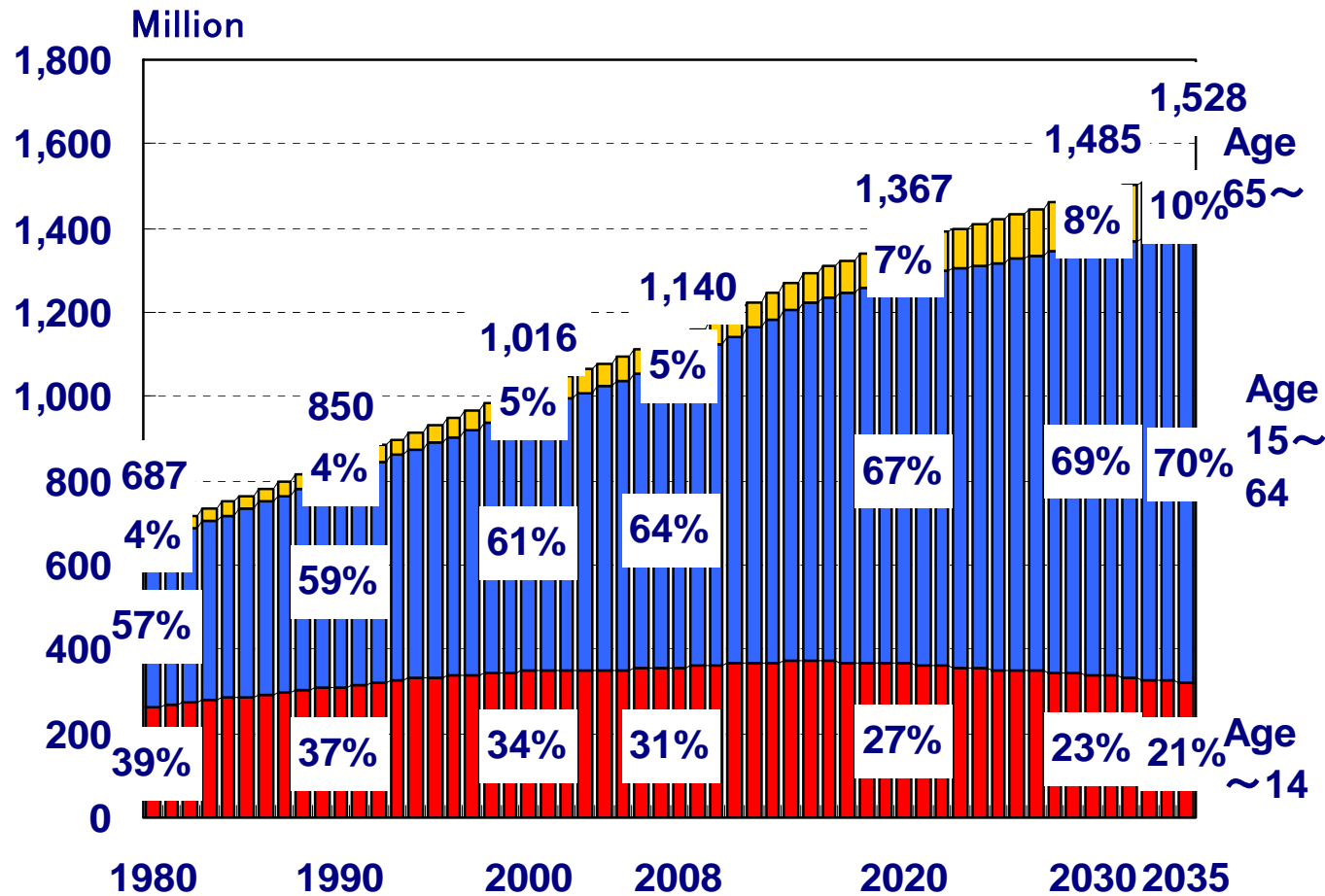


【Nitrogen Fertilizer】

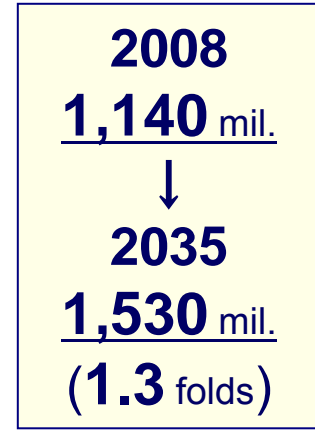


- Infrastructure development, and expansion of manufacturing industry will result in sharp increases in crude steel, cement and ethylene productions.
- Nitrogen fertilizer production will grow moderately in accordance with the projected moderate growth of agriculture production.

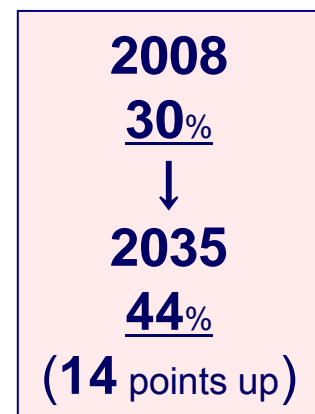
Population in India



Total Population

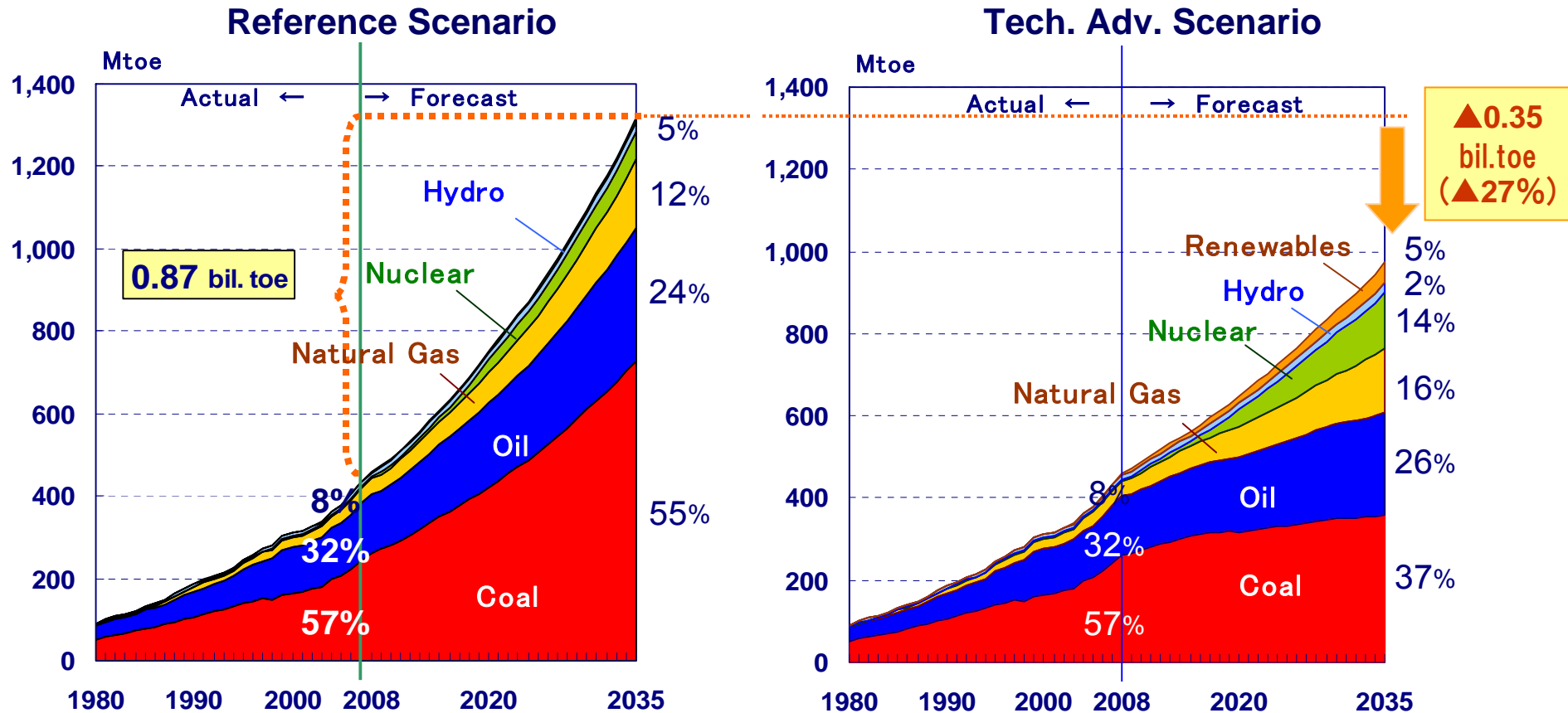


Urbanization Rate



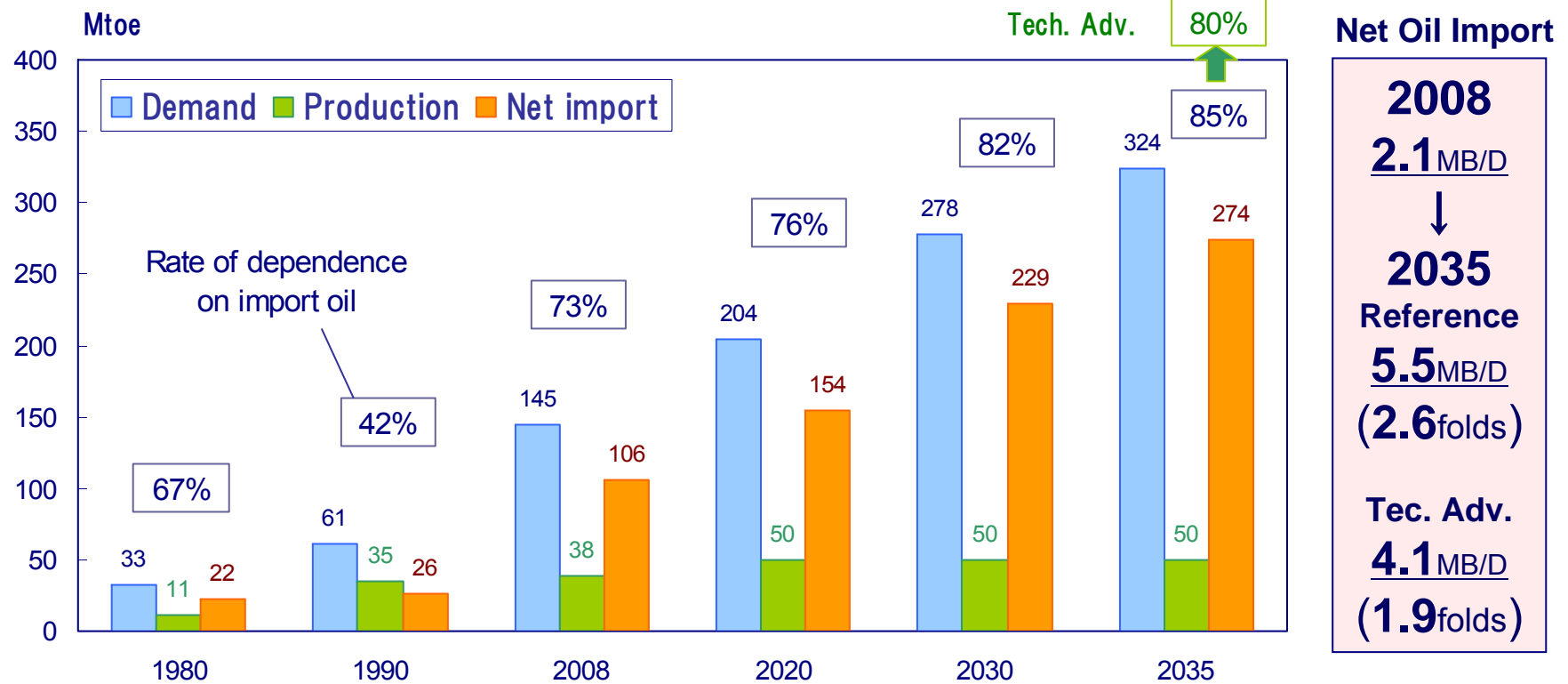
- Growing at an annual rate of 1.1%, total population will reach 1.5 billion in 2035 to become the world's most populous country.
- The share of labor population will continue to increase, reaching 70% of the total in 2035.
- The share of urban population will increase to 44% in 2035 from 30% in 2008.

Primary Energy Demand in India



- In the Reference Scenario, TPED will increase rapidly at annual rate of 4%. Fossil fuels will account for 90% of the incremental energy growth by 2035.
- Driven by the power and industry sectors, coal demand will represent the largest share in TPED accounting for 55% in 2035.
- The power and industry sectors will lead natural gas demand growth. Development of domestic resources is expected, while much of the natural gas demand should be met by import.
- By 2035, compared with the Reference Scenario, TPED will be 350 Mtoe lower (27%) in the Tech. Adv. Scenario.

Oil Demand and Supply in India



Net Oil Import

2008
2.1 MB/D

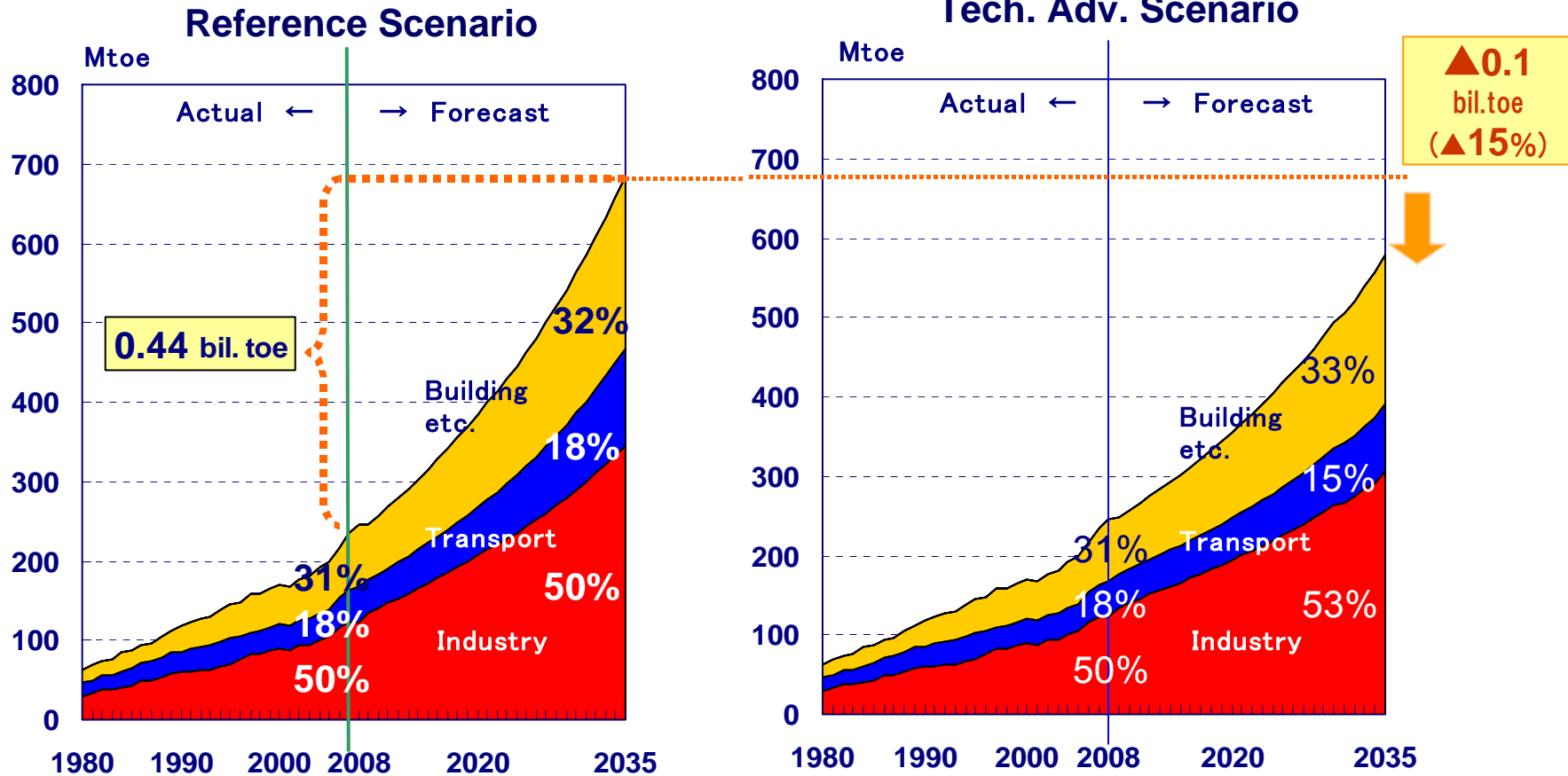
↓

2035
 Reference
5.5 MB/D
 (2.6 folds)

Tec. Adv.
4.1 MB/D
 (1.9 folds)

- Net oil import is projected to expand from 110 million ton (2.1 mb/d) in 2008 to 270 million ton (5.5 mb/d) in 2035. Net oil import ratio will reach 85% in 2035.
- In the Technologically Advanced scenario, net oil import ratio will reach 80% by 2035.

Final Energy Demand in India

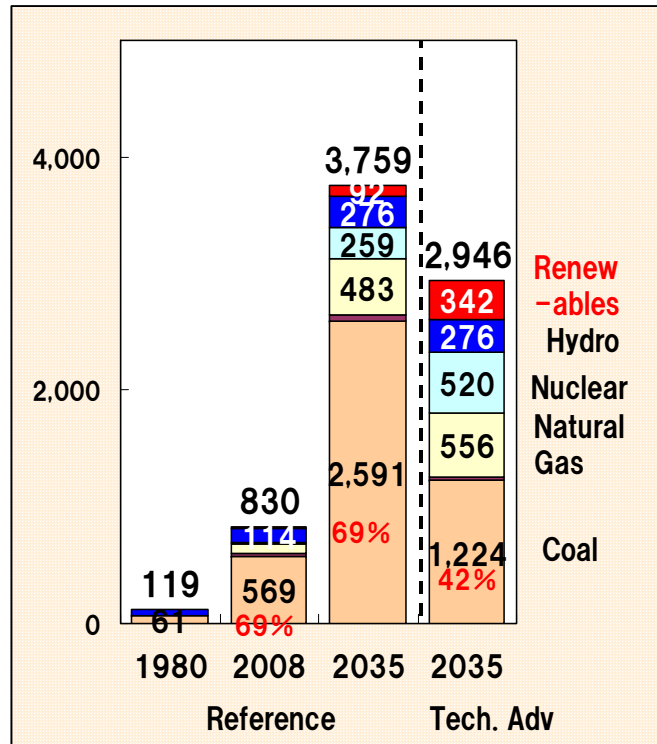


(The industry sector includes non-energy use)

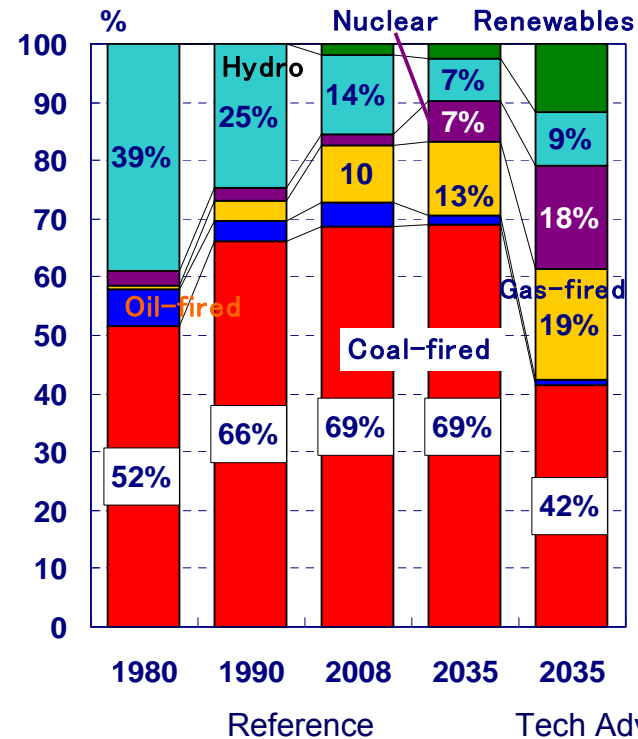
- Industry will increase rapidly due to industrialization and production increases from the heavy industry.
- Electricity demand will be led by the household, building, and industry sectors, growing at an annual rate of 5.9%. Per capita electricity demand will increase to 1,857kWh in 2035 (20% of that of Japan in 2008).
- In the Techn. Adv. Scenario, energy demand will be 100 Mtoe lower (15%) in 2035 compared with the Reference Scenario.

Power Generation Mix in India

【Power Generation】

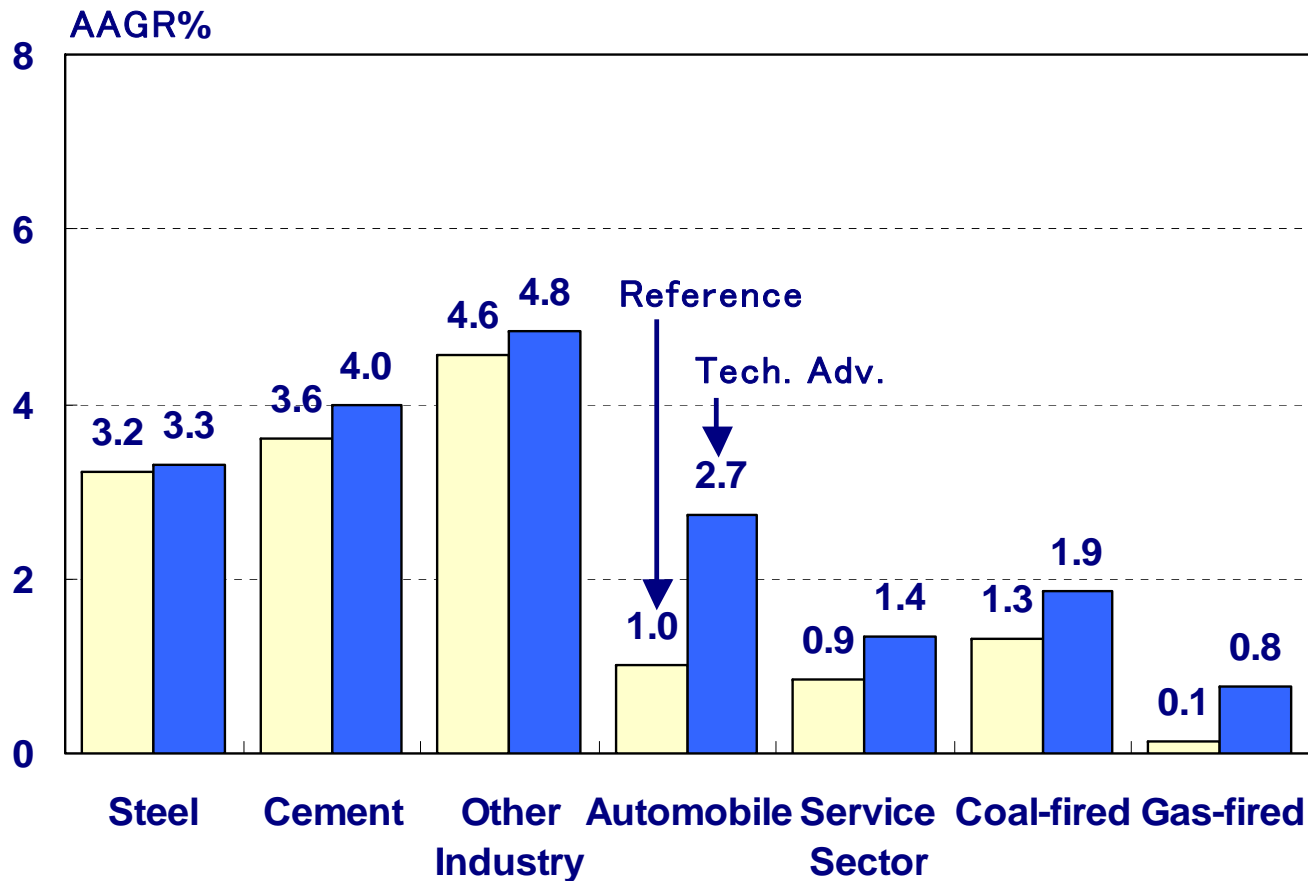


【Power Generation Mix】



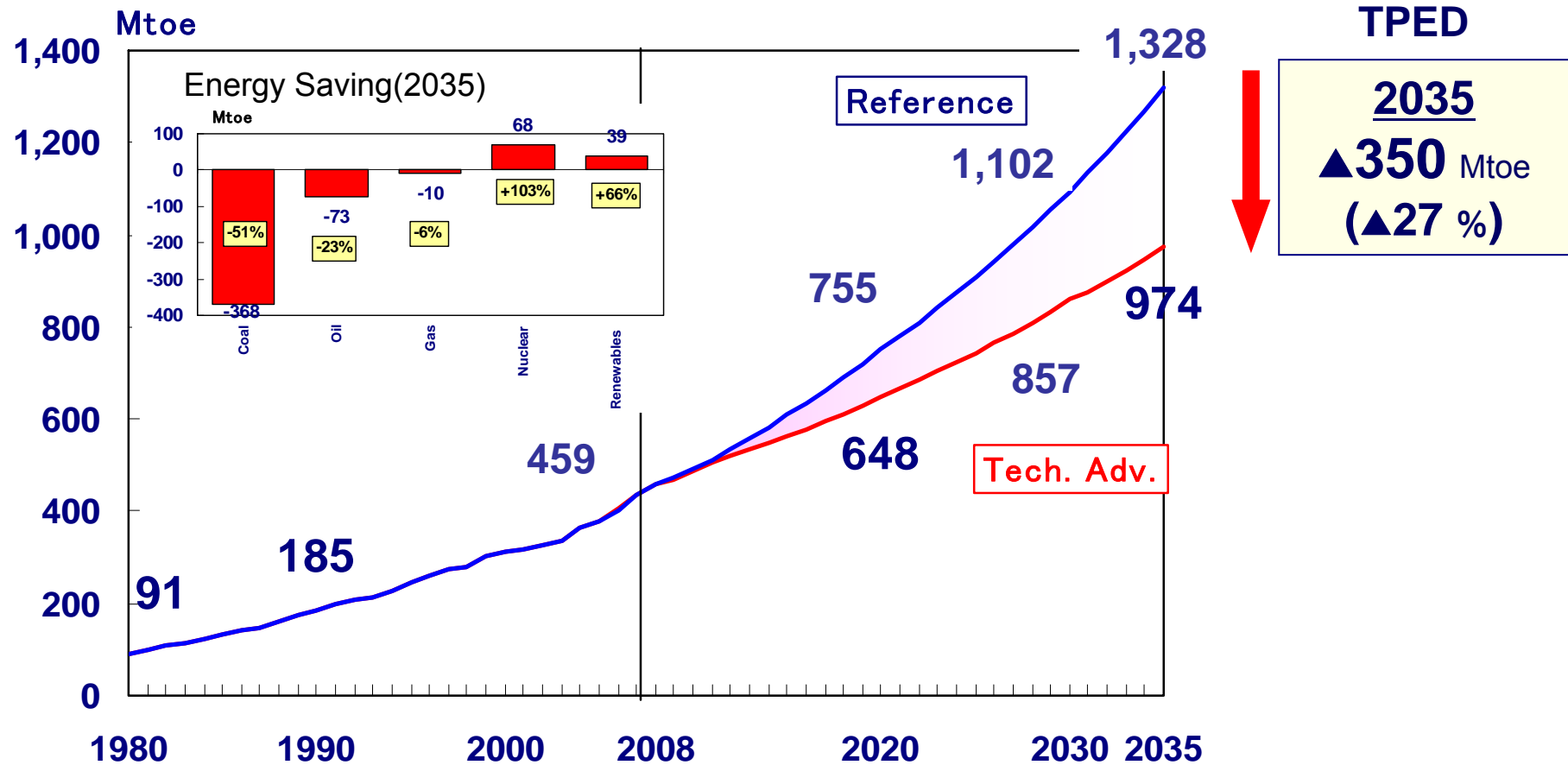
- In the future, coal-fired power will continue to account for the largest share, while generation efficiency may improve led by the government's Ultra Mega Power Project to introduce several 4GW-class super critical coal-fired power plants.
- On the other hand, the share of natural gas and nuclear will gradually expand and power generation mix will become more diversified.
- Capacity of nuclear will increase from 4.1 GW in 2008 to 33 GW in 2030 (an 8.8-fold increase).

Energy Efficiency Improvement by Sector



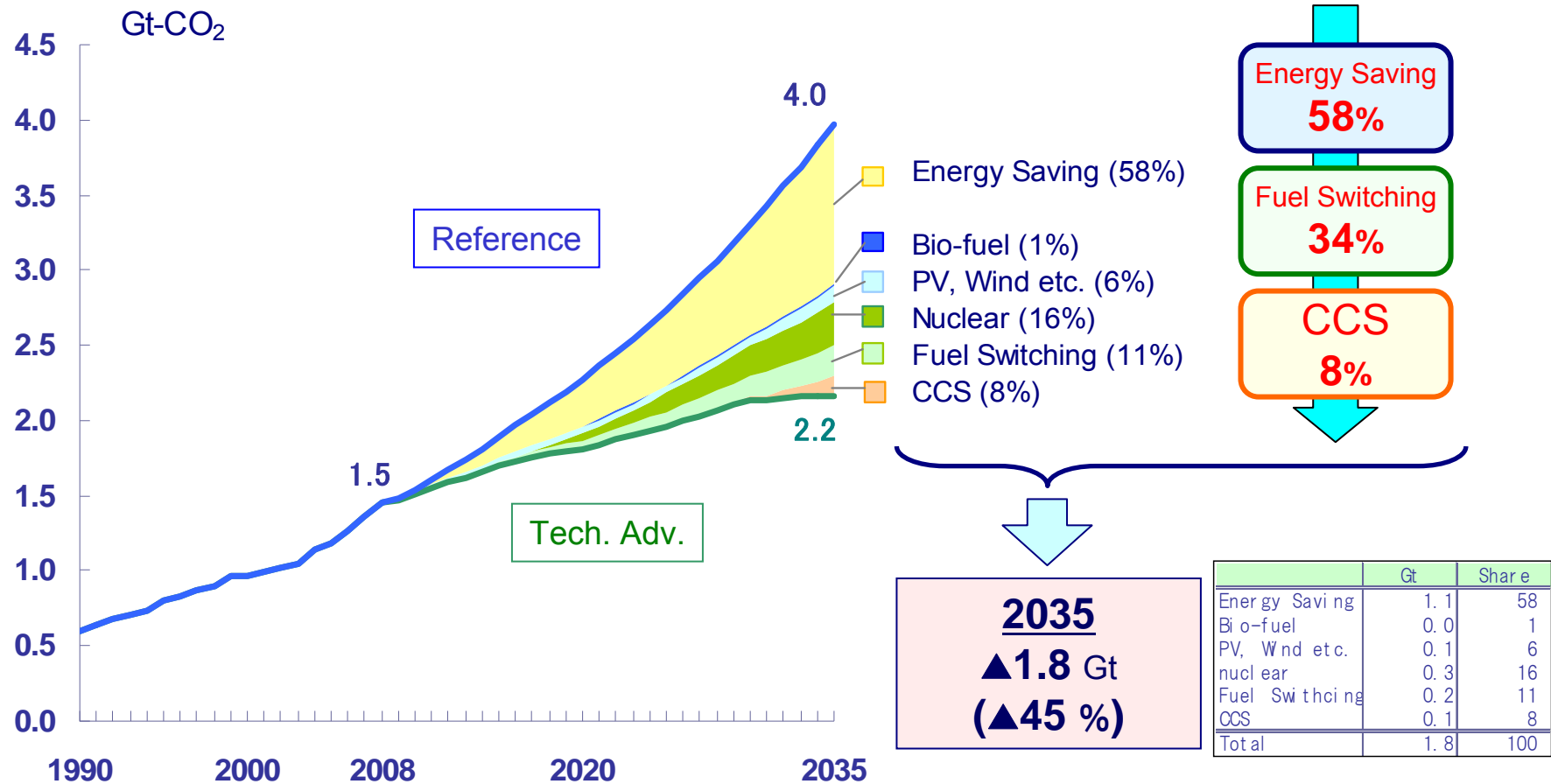
- Newly built factories in India will introduce production systems, with high energy efficiency levels, comparable to international standards. This will be realized with the uptake of various technologies, including pulverized coal injection and blast furnace gas, new type kilns, highly efficient furnaces, motors, and boilers.
- Policies and measures need to be introduced to promote purchase of energy efficient products for the household customers.

Primary Energy Demand in India



- In the Tech. Adv. Scenario, India's primary energy demand will be 350 Mtoe lower in 2035 compared with the Reference Scenario.
- Substantial reduction in coal demand (calculated as difference between the Tech. Adv. Scenario and the Reference Scenario) at 370 Mtoe is expected due to the introduction of **84** clean coal technology.

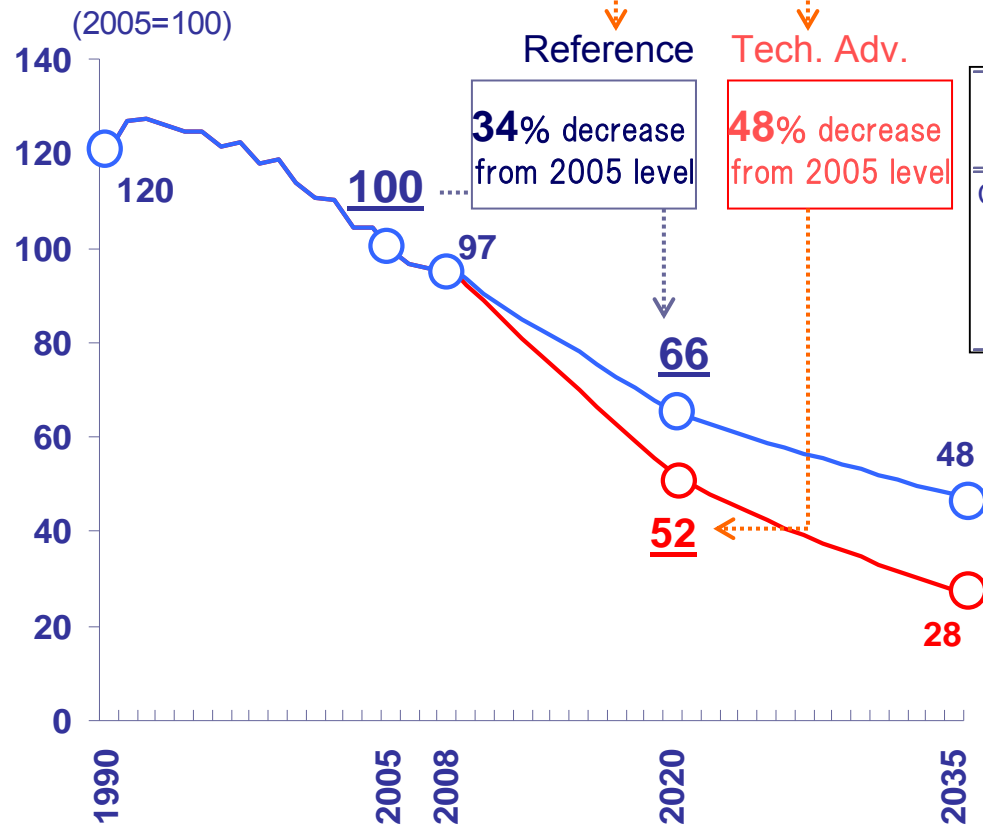
CO₂ Emissions Reduction in India



- In the Reference Scenario, CO₂ emission will increase by 2.5 Gt (173%) in 2035 from 2008.
- In the Tech. Adv. Scenario, CO₂ emissions will be 1.8 Gt (46%) lower from the Reference Scenario.

CO₂ Emissions per GDP

National Target : 20 to 25% reduction by 2020 Decomposition Analysis of CO₂ Emissions



	1990-2005	2005-2020	
		Reference	Tech. Adv.
CO ₂ Emissions ΔC	4.7	4.4	2.8
Carbon Intensity $\Delta(C/E)$	▲ 0.2	▲ 0.2	▲ 0.8
Energy Saving $\Delta(E/Y)$	▲ 1.0	▲ 2.5	▲ 3.5
Economic Growth ΔY	6.0	7.4	

$$C = (C/E) * (E/Y) * Y$$

$$\Delta C = \Delta(C/E) + \Delta(E/Y) + \Delta Y$$

Decarbonization / Energy-Saving / Economic-Growth

- India announced to improve its CO₂ intensity (calculated as CO₂ emissions per GDP) by 20 to 25% from 2005 level by 2020.
- CO₂ emissions per GDP in 2020 will improve from 2005 level by 34% in the Reference Scenario and 48% in the Tech. Adv. Scenario.

Beyond 2035; Asia/World Energy Outlook through 2050

GDP, Population and Energy Price

	2008	2035	2050
GDP (2000 real price)	40 tril. \$ (AAGR in 1990-2008:2.9%)	84 tril. \$ (AAGR in 2008-2035:2.8%)	112 tril. \$ (AAGR in 2035-2050:1.9%) (AAGR in 2008-2050:2.5%)
Population	6.7 bil.	8.5 bil. (1.8 bil. increase from 2008)	9.1 bil. (2.4 bil. increase from 2008)
GDP per Capita	6 thousand \$	10 thousand \$	12 thousand \$
Oil Price (On a Japanese CIF basis, 2009 real price)	(2009) 60 \$/bbl	115 \$/bbl (Nominal price:192 \$/bbl)	120 \$/bbl (Nominal price:270 \$/bbl)

- Global GDP will grow annually at 2.5% from 2008 to 2050.
- World total population will expand from 6.7 bil. in 2008 to 9.1 bil. in 2050.
- Crude oil price (on a Japanese CIF basis, 2009 real price) is assumed to increase from 60\$/bbl in 2009 to 120 \$/bbl in 2050.

Assumed Energy and Environmental Technologies

	2008 Actual	2035		2050	
		Reference	Tech. Adv.	Reference	Tech. Adv.
Nuclear	390 GW	615 GW	830 GW	840 GW	1,190 GW
Conversion Efficiency	Coal:34% Gas:40%	Coal: 40% Gas: 47%	Coal: 45% Gas: 50%	Coal: 41% Gas: 48%	Coal: 51% Gas: 53%
Photovoltaic	13 GW	165 GW	594 GW	450 GW	1,810 GW
CSP	0.3 GW	37 GW	127 GW	50 GW	410 GW
Wind	120 GW	467 GW	921 GW	870 GW	1,820 GW
Biomass Power Gen.	67 GW	210 GW	235 GW	300 GW	320 GW
Biofuel	48 Mtoe	164 Mtoe	272 Mtoe	200 Mtoe	350 Mtoe
CCS	-	0	2.6 bil. ton	0	10.1 bil. ton
Adv. Vehicle in Annual Sales PHEV EV/FCV	-	6% 0%	14% 13%	9% 2%	30% 32%
Average Fuel Efficiency of new vehicle sales	(2005) 12 km/L	17 km/L	25 km/L	18 km/L	30 km/L

CSP: Concentrated Solar Power, **CCS:** Carbon Capture and Storage, **PHEV:** Plug-in Hybrid Electric Vehicle, **EV:** Electric Vehicle, and **FCV:** Fuel Cell Vehicle

Outlook on Vehicle Stocks and Sales (World)

【Breakdown of Vehicle Stocks (World)】

【Breakdown of Annual Sales (World)】

Share of clean energy vehicle on total stock (2050)

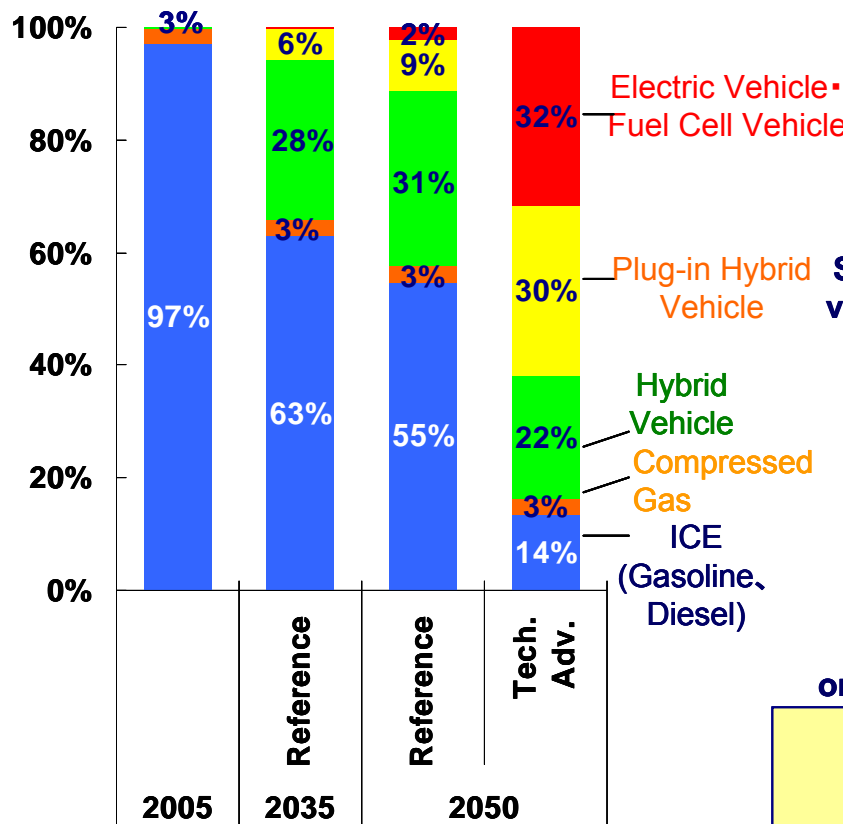
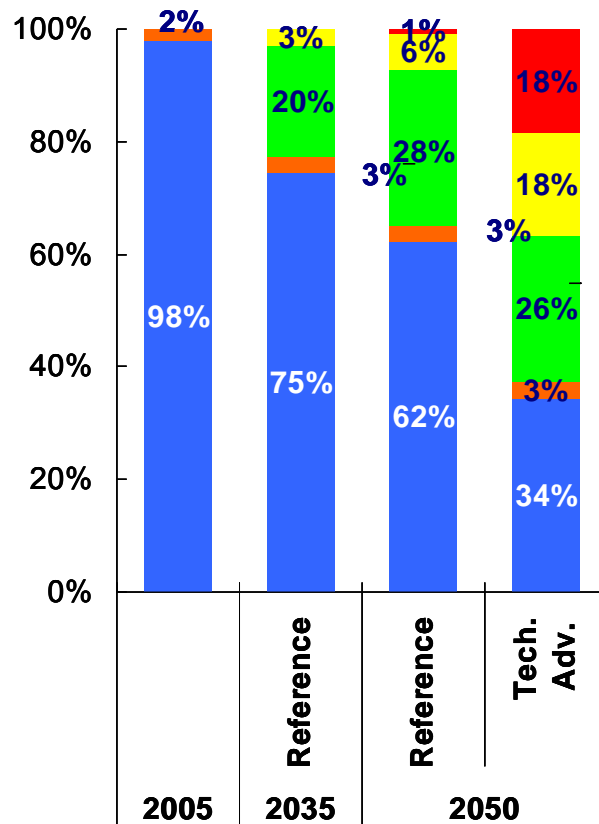
Reference
38 %
Tech. Adv.
66 %

Share of clean energy vehicle in annual sales (2050)

Reference
45 %
Tech. Adv.
86 %

Fuel Efficiency on Annual Sales basis

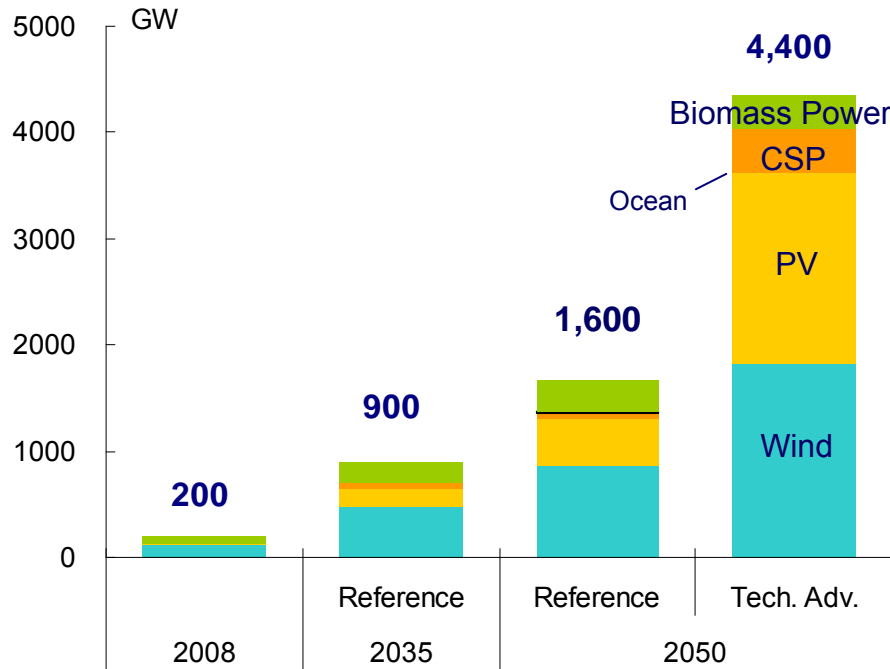
(2005)
12km/L
(2050)
Reference Tech. Adv.
18km/L 30km/L



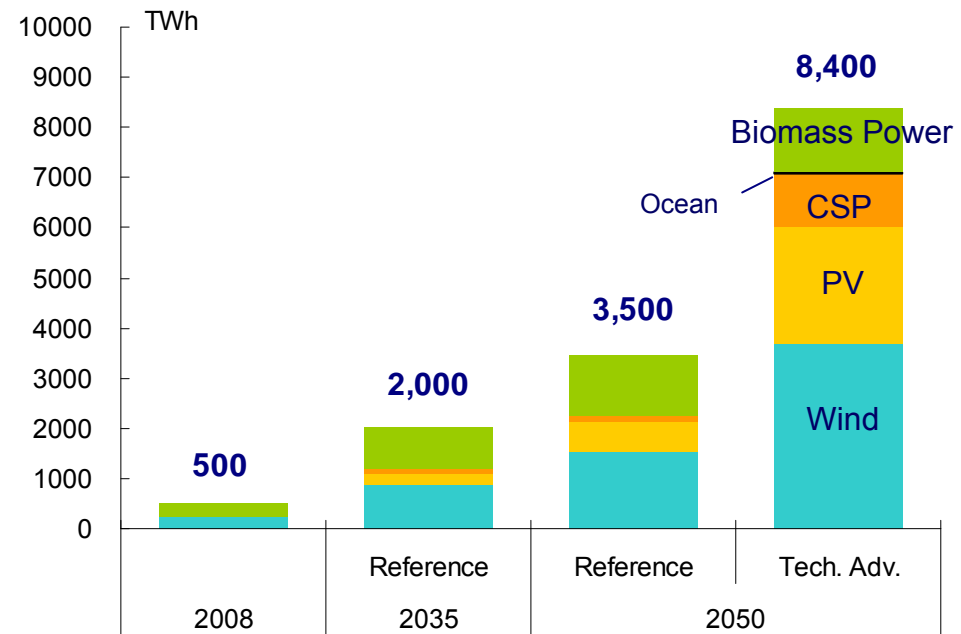
In the Tech. Adv. Scenario, approximately 80% of new vehicles in 2050 is composed of clean energy vehicles.

Renewable Power Generation (World)

Electric Power Capacity



Electric Power Generation

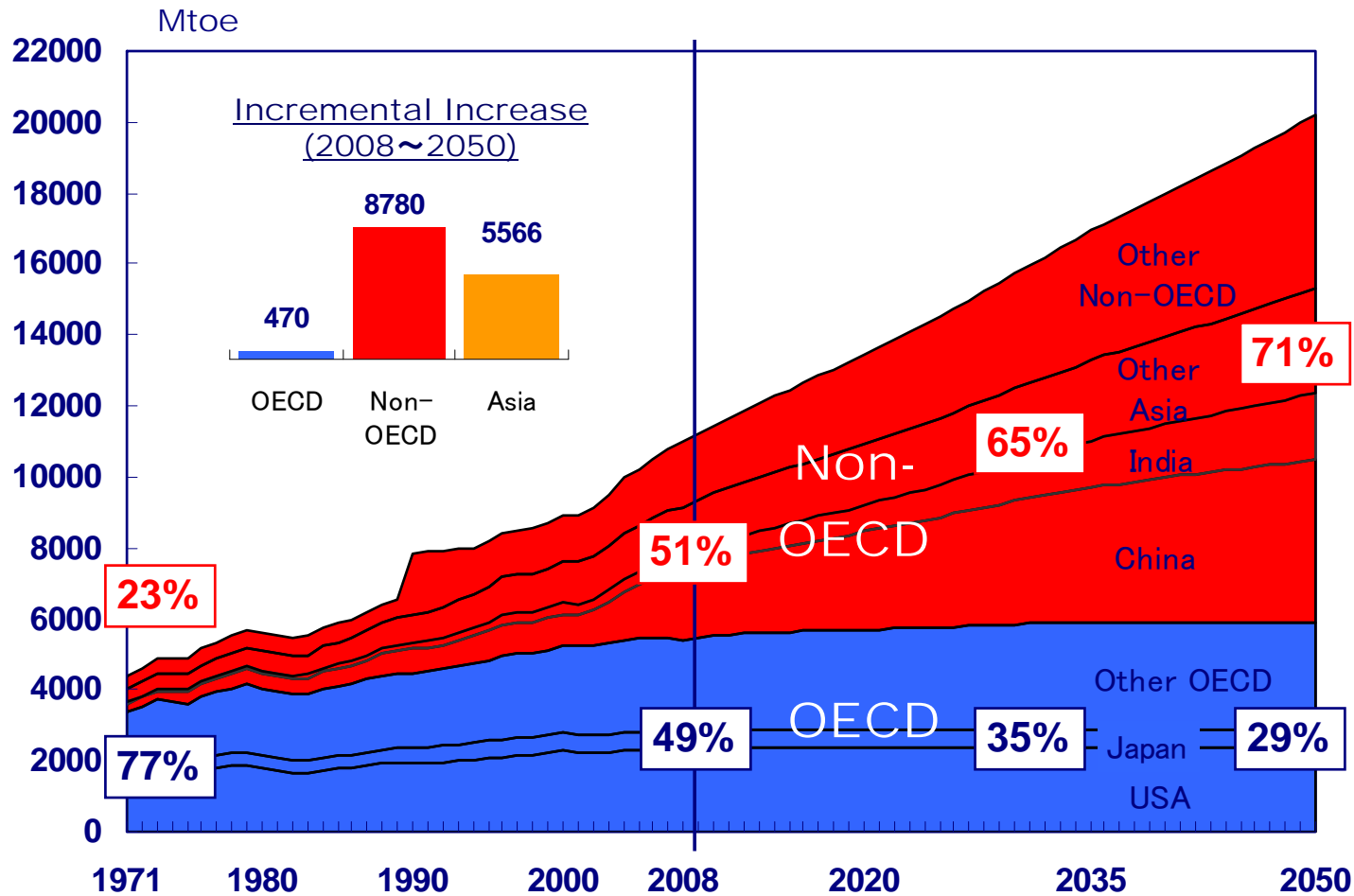


■ In the Tech. Adv. Scenario, by 2050, renewable power generation capacity, excluding hydro, will expand 168 times as much as that of 2008.

■ Wind power capacity in 2050 will exhibit a 15-fold increase compared with that in 2008; PV capacity, 135-fold increase; CSP capacity, 1190-fold increase; ocean energy capacity, 21-fold increase; biomass capacity, 5-fold increase.

Primary Energy Demand (World)

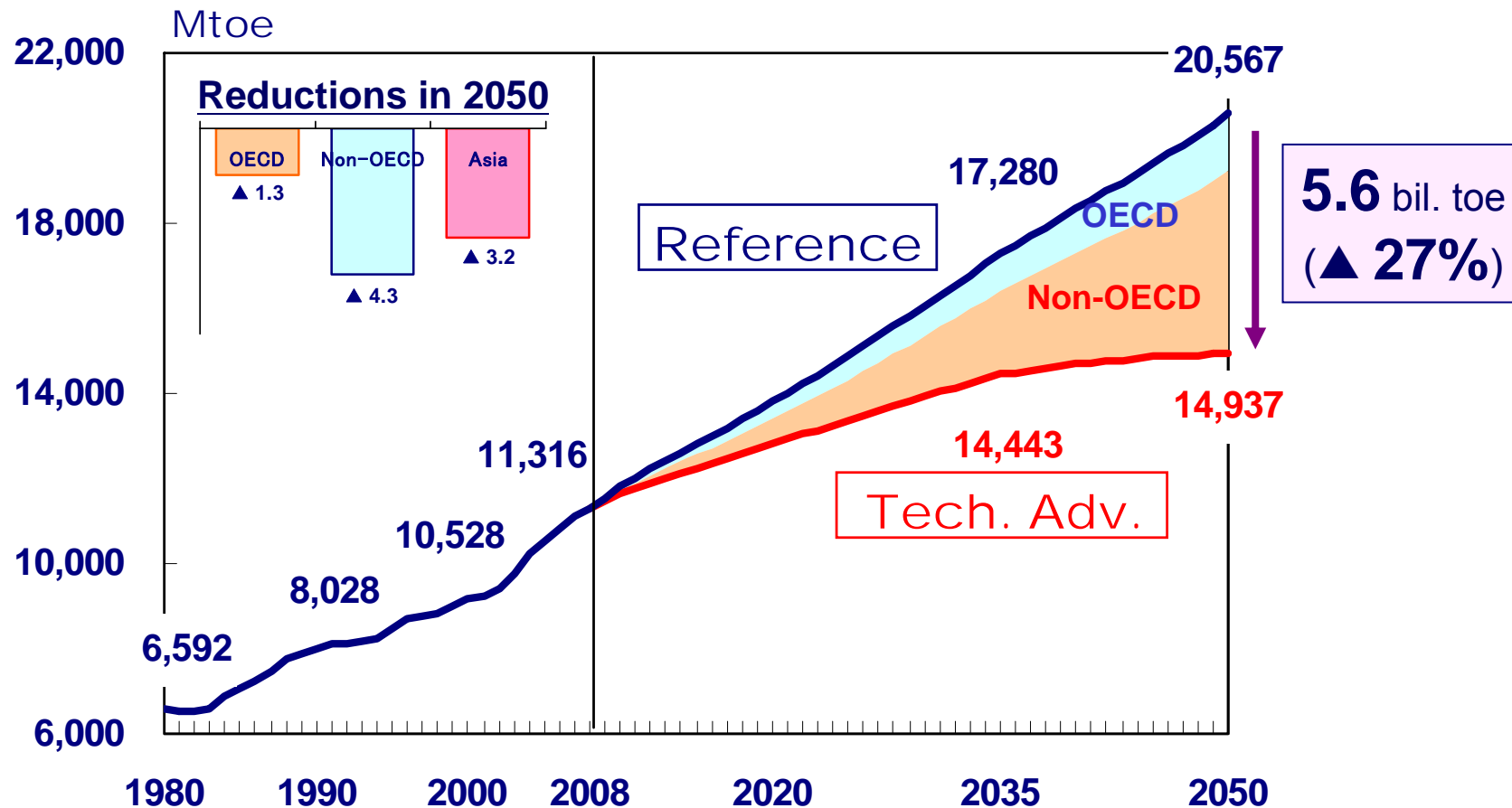
Reference



- World primary energy demand will increase from 11.3 Btoe in 2008 to 20.6 Btoe in 2050, showing a 1.8-fold increase from 2008.
- The share in primary energy of Non-OECD in the world will expand to approximately 70% by 2050 from 50% in 2008 at the expense of OECD's decreased share.

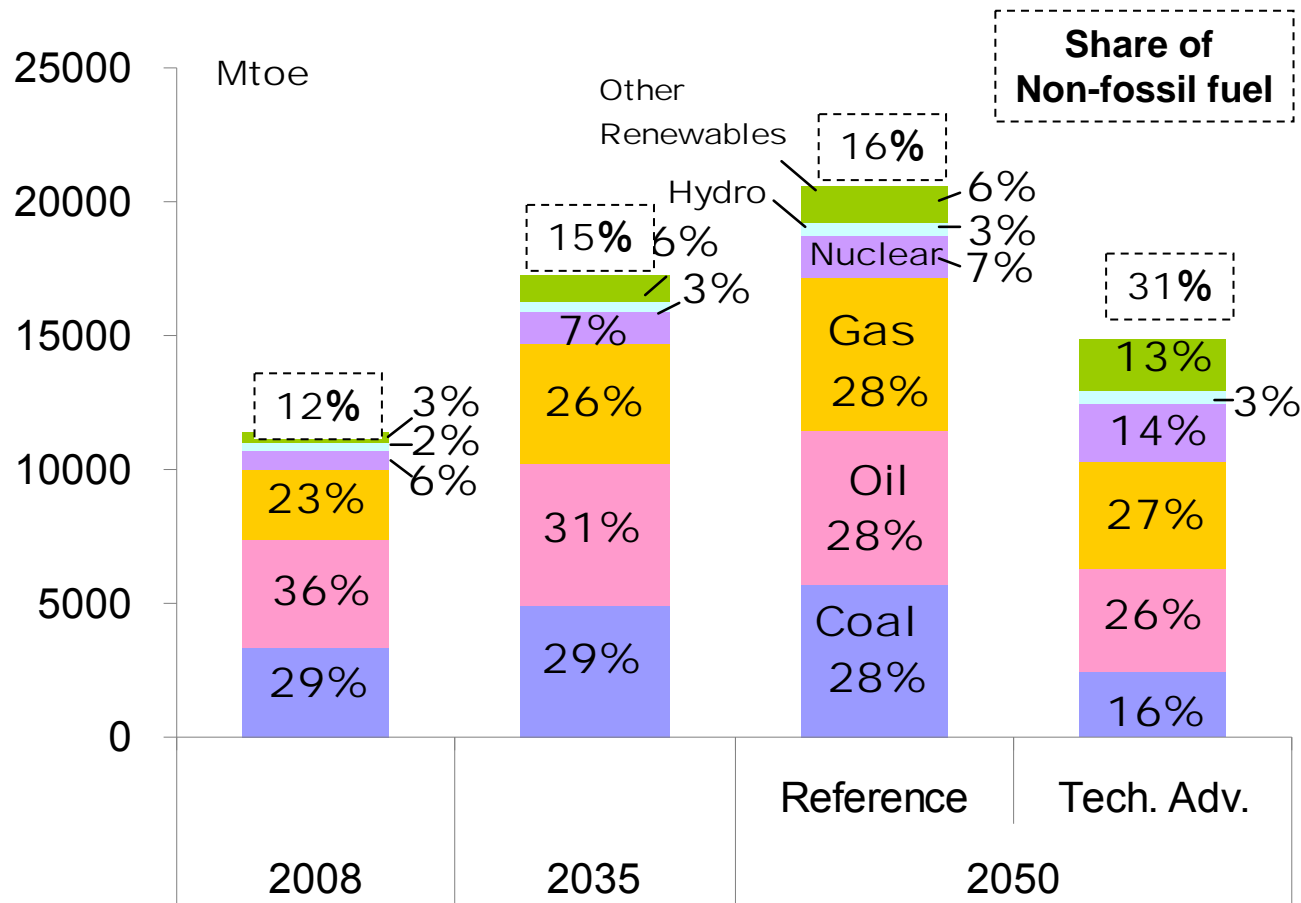
Primary Energy Demand (World)

Reference, Tech. Adv.



- The world primary energy demand will peak around 2050 in the Tech. Adv. Scenario.
- In 2050, world total primary energy demand in the Tech. Adv. Scenario will decrease by 5,600 Mtoe in comparison with the Reference Scenario. The projected TPED saving of Non-OECD in 2035 at 4,300 Mtoe is 3.3 times as large as that of OECD.

Primary Energy Demand (World, by Type)

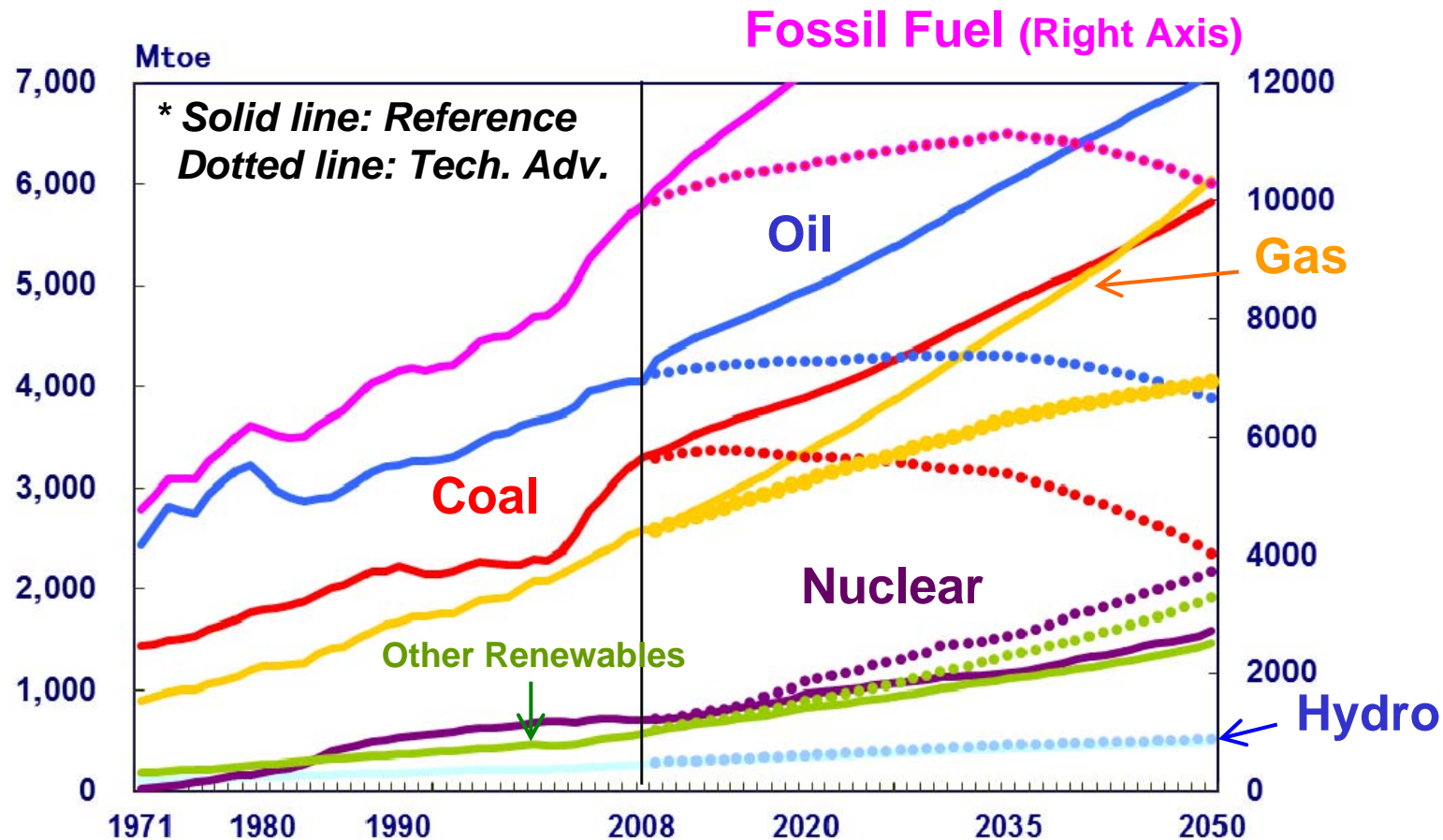


Increasing Ratio in 2050 (from 2008)

	Reference	Tech. Adv.
Coal	72%	▲ 27%
Oil	42%	▲ 5%
Gas	119%	56%
Nuclear	115%	197%
Hydro	89%	85%
Oth. Renew.	268%	445%
Total	82%	32%

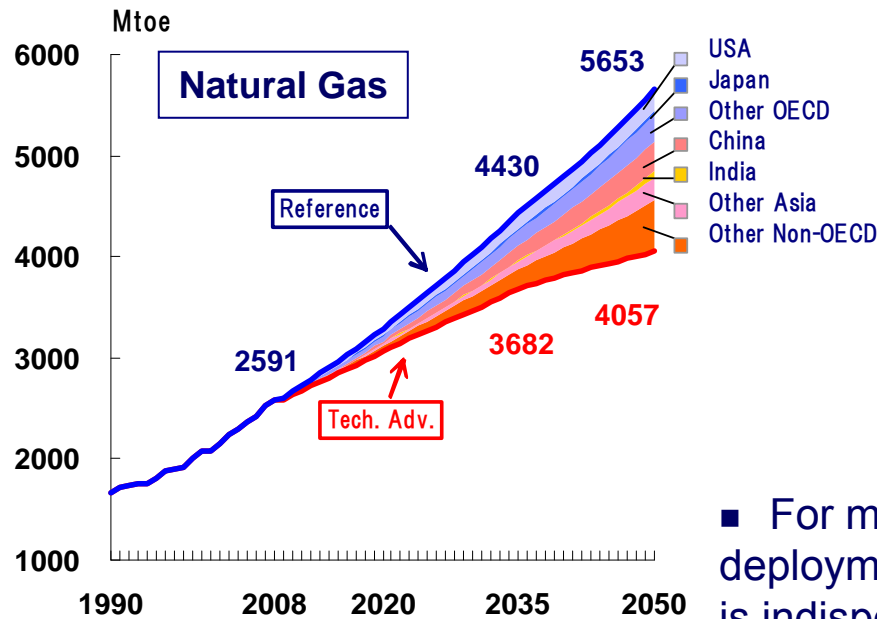
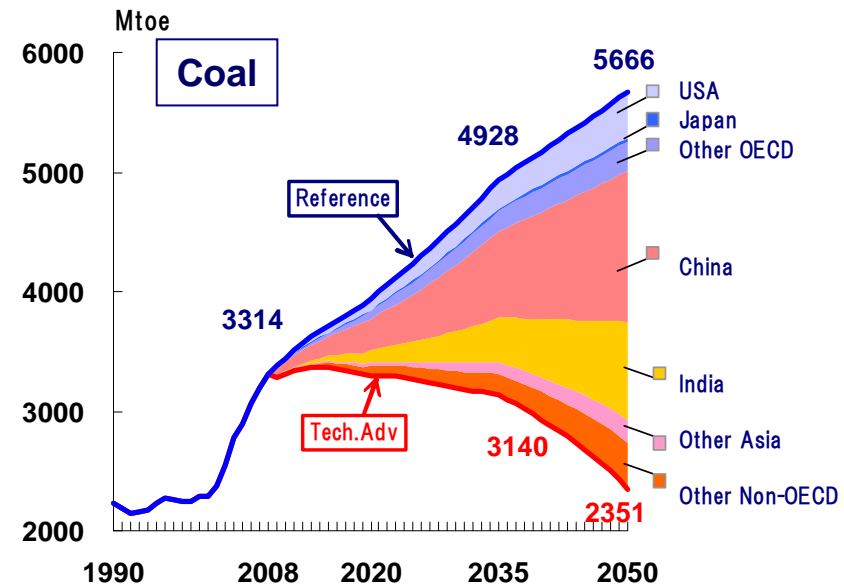
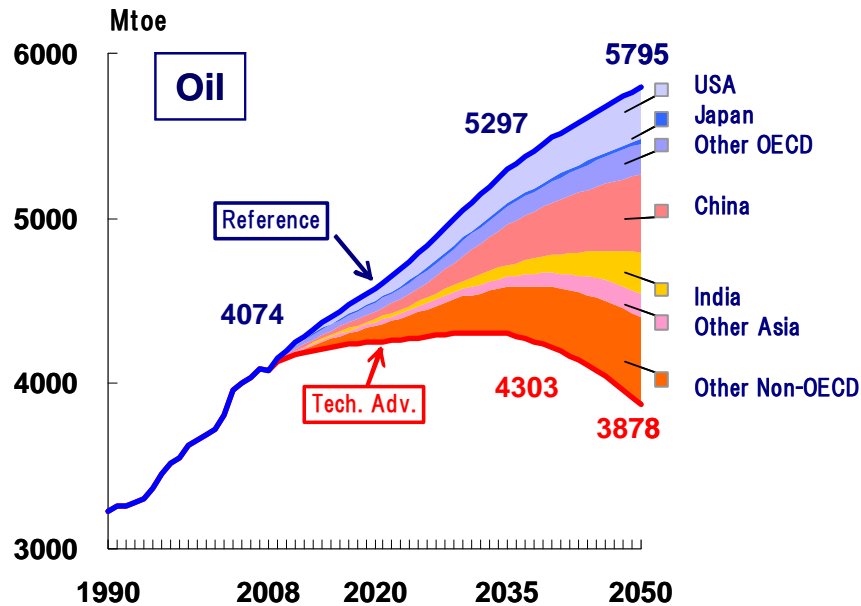
- Even under the Tech. Adv. Scenario, fossil fuel will dominate primary energy mix with its share at 69% in 2050. Natural gas, in particular, will continuously expand its portion in the world primary energy mix both in the Reference and Tech. Adv. Scenario.
- The share of non-fossil fuel in world primary energy will amount to 16% in the Reference and 31% in the Tech. Adv. Scenario.

Primary Energy Demand (World, by Type)



- Fossil fuel demand will peak in 2035 under the Tech. Adv. Scenario.
- In the Tech. Adv. Scenario, the world oil demand will decrease from 82 mbd in 2008 to 78 mbd in 2050, and world coal, from 4.6 Btce in 2008 to 3.4 Btce in 2050.
- By contrast, natural gas demand will continue to increase towards 2050 even in the Tech. Adv. Scenario. Adequate investment needs to be maintained to explore and develop natural gas resources.

Fossil Fuel Demand



Reduction in 2050 (Regional Breakdown)

(Oil)

	Mtoe	Share
USA	315	16%
Japan	25	1%
Other OECD	188	10%
China	471	25%
India	253	13%
Other Asia	141	7%
Other Non-OECD	525	27%
OECD	528	28%
Non-OECD	1389	72%
Developing Asia	865	45%
World	1917	100%

(Coal)

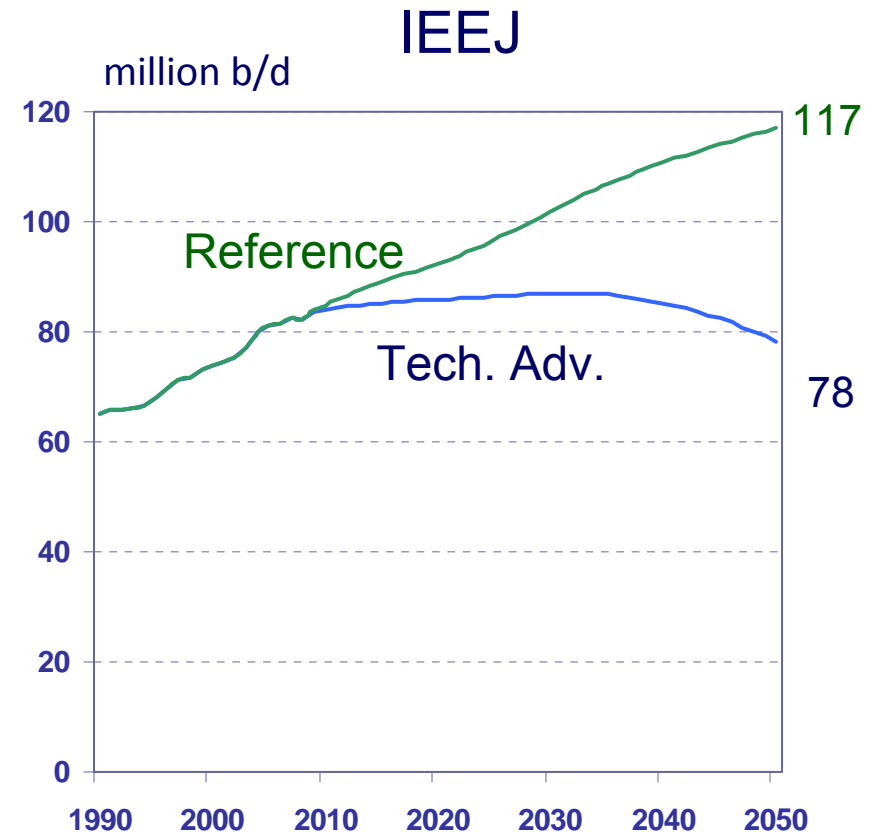
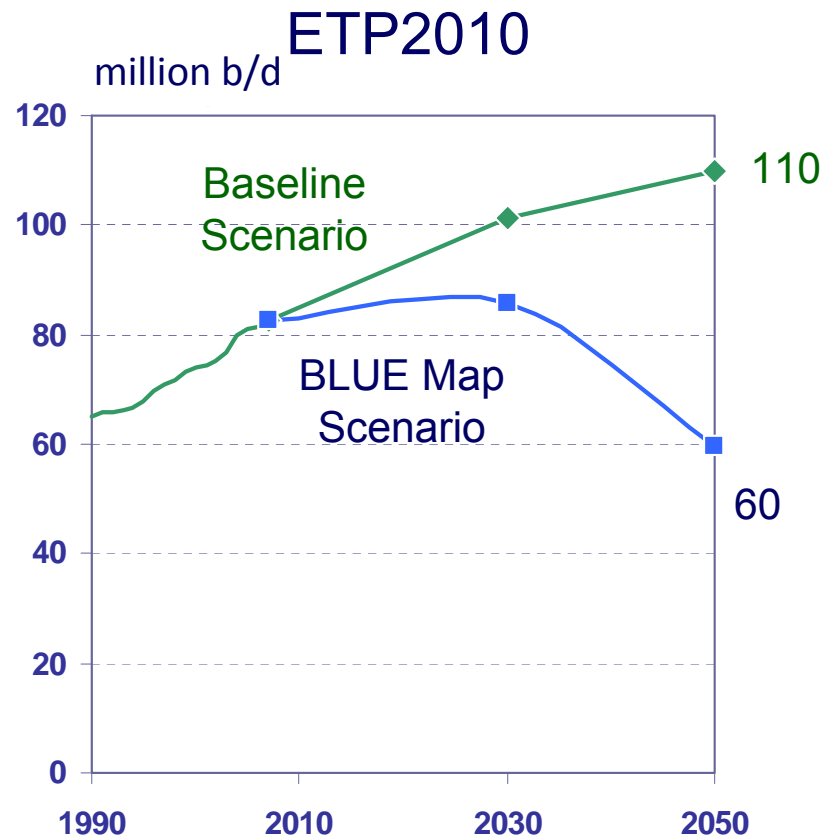
	Mtoe	Share
USA	384	12%
Japan	27	1%
Other OECD	247	8%
China	1260	38%
India	795	24%
Other Asia	191	6%
Other Non-OECD	384	12%
OECD	658	20%
Non-OECD	2631	80%
Developing Asia	2247	68%
World	3289	100%

(Natural Gas)

	Mtoe	Share
USA	233	14%
Japan	31	2%
Other OECD	281	17%
China	296	18%
India	67	4%
Other Asia	212	13%
Other Non-OECD	512	31%
OECD	545	33%
Non-OECD	1087	67%
Developing Asia	575	35%
World	1632	100%

■ For mitigation of the impact of fossil fuel use, the deployment of efficient technologies using fossil energy **96** is indispensable particularly in developing Asia.

Comparison with IEA's ETP 2010 : Oil Demand

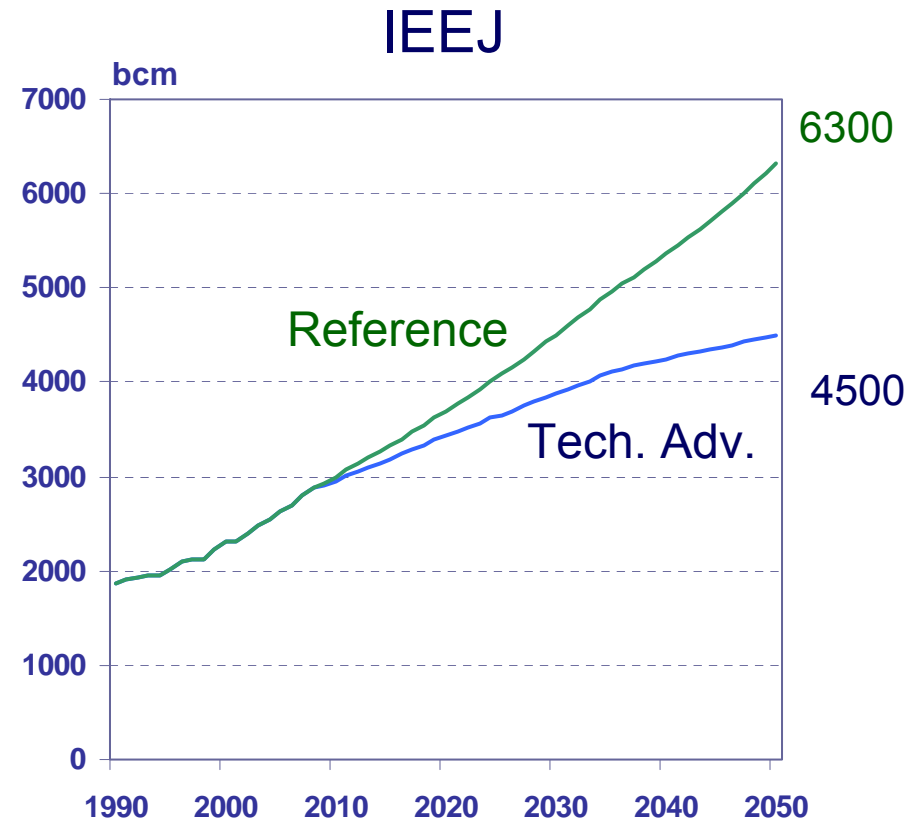
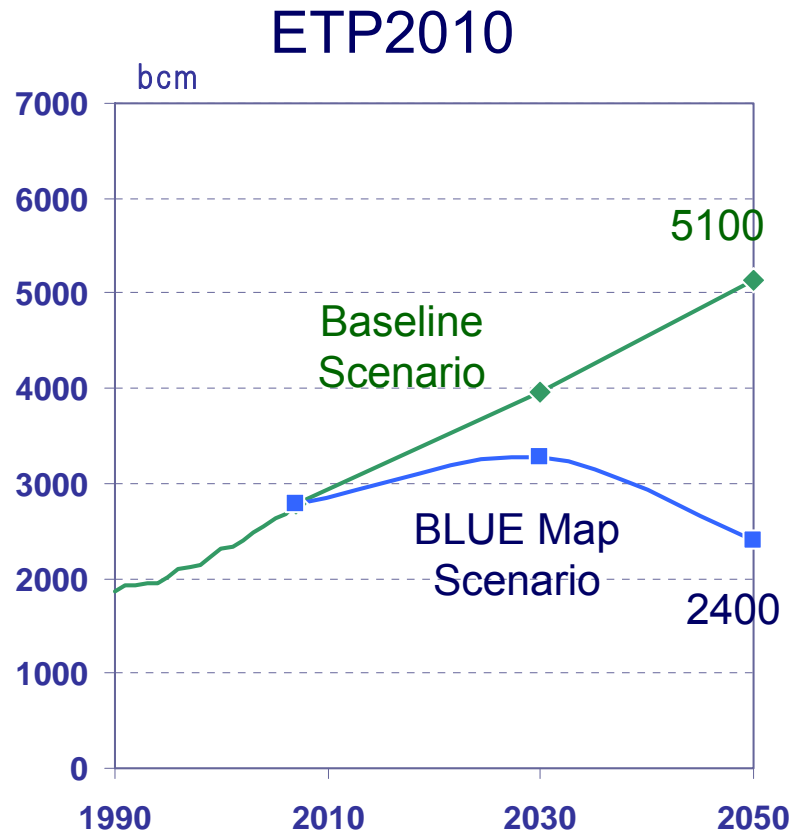


■ Under the IEA's BLUE Map Scenario in "Energy Technology Perspectives (ETP) 2010", which analyzes the options to reduce CO₂ emissions by 50% through 2050, the world's liquid fuel demand is projected to reach 82 million barrels per day. Of this total, oil will account for 77%, and biofuel will account for the remaining 23%.

■ In the BLUE Map Scenario, OPEC's crude oil production would have to be maintained at the 2007 level, suggesting the need for continued investment toward upstream oil exploration and development.

■ In the IEEJ's Technologically Advanced Scenario, oil demand is projected to reach its peak in 2030, while oil will maintain the dominant share in total primary energy demand through 2050.

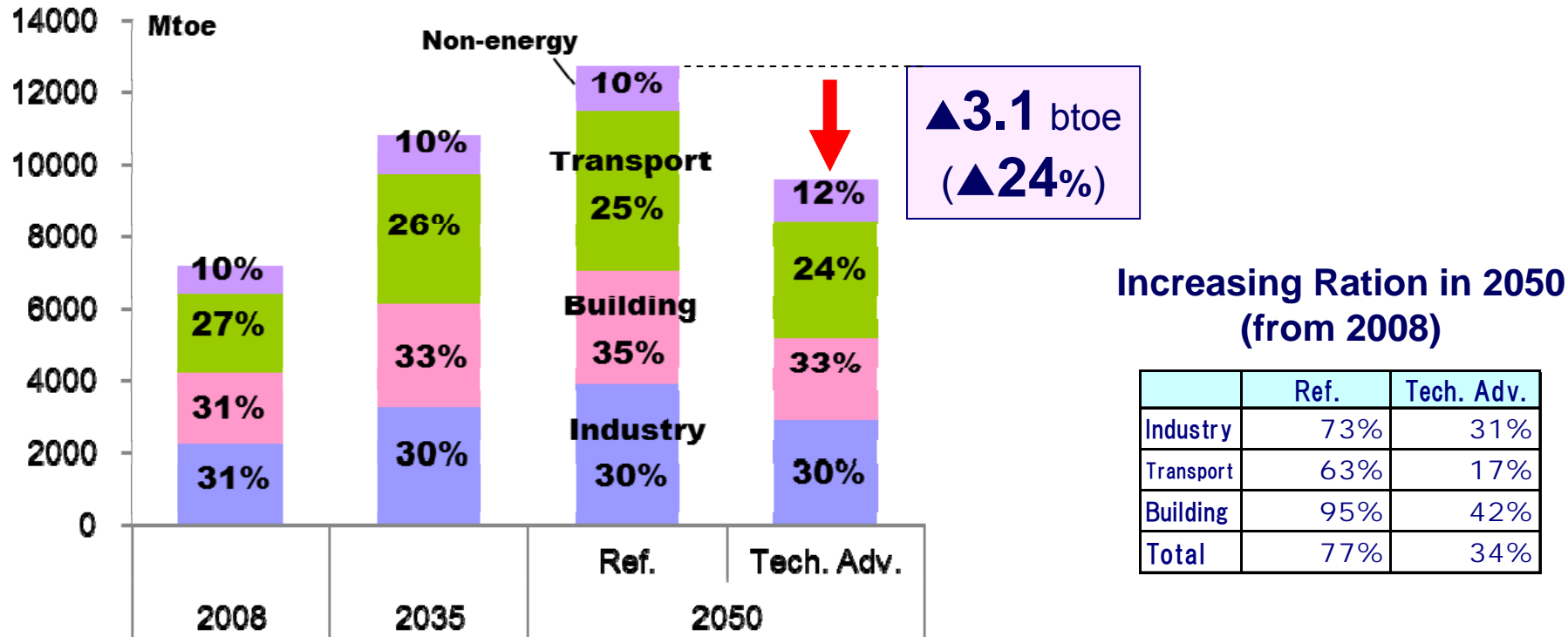
Comparison with IEA's ETP 2010 : Natural Gas Demand



■ Under the Baseline Scenario, IEA projects that the world natural gas demand will increase 1.85 times between 2007 and 2050. In the BLUE Map Scenario, natural gas demand will peak sometime around 2030 to decline thereafter, and by 2050 natural gas demand will reach a level 85% below that of 2007.

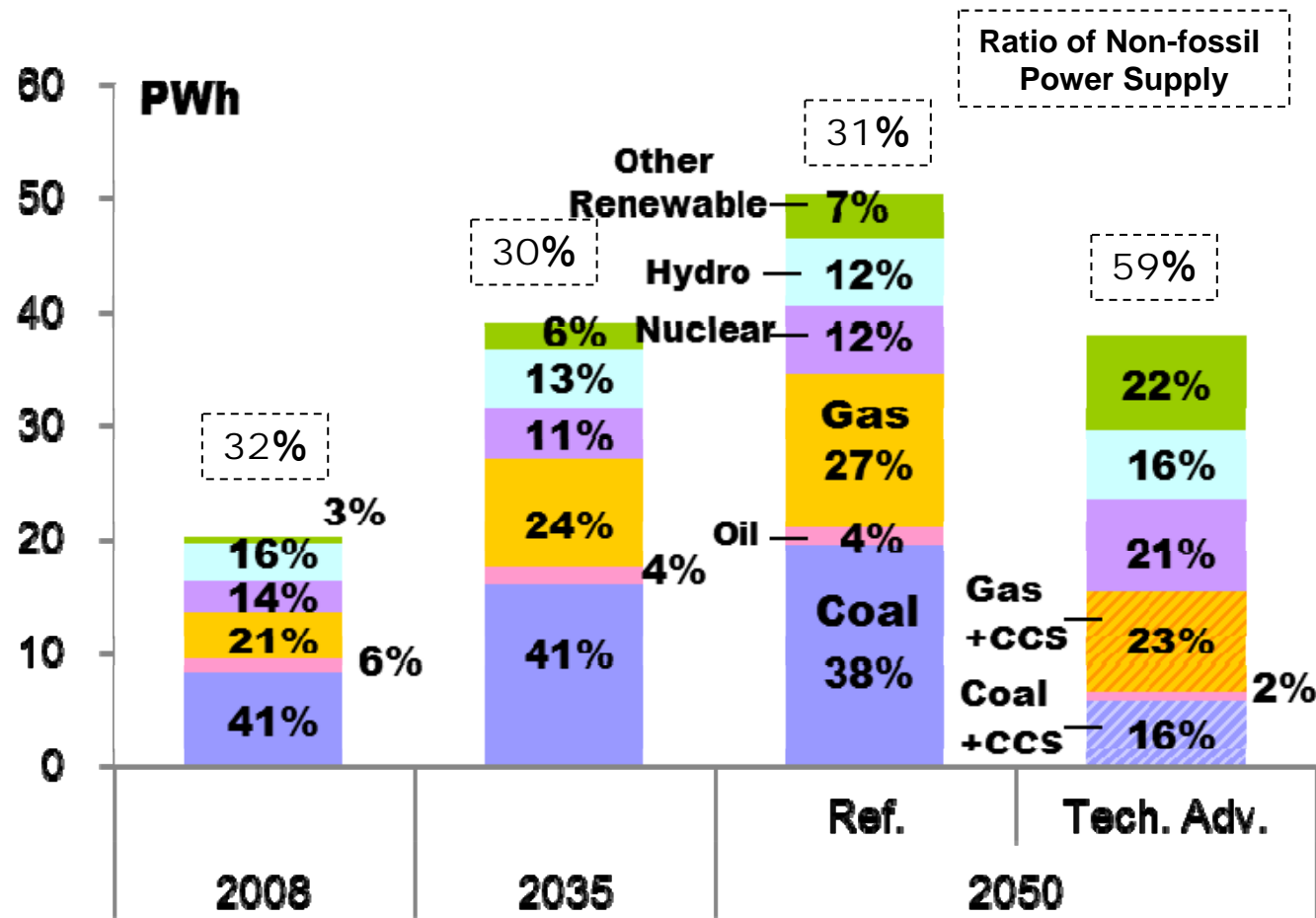
■ IEEJ projects that for both the Reference and Tech. Adv. Scenario, the world's natural gas demand will continue to increase mainly driven by fuel switching in the power and industry sectors of Non-OECD, suggesting the need for appropriate investment for natural gas resources development to meet increasing demand.

Final Energy Demand (World)



- In the Reference Scenario, the world total final energy demand will increase by 77% from 2008, and in the Tech. Adv. Scenario by 34%. In both cases, end-use demand in industry, transport and building will increase from 2008 to 2050.
- In the Tech. Adv. Scenario, the world total final energy demand in 2050 will decrease by 3.1 Btoe, or 24% decline from the Reference Scenario.

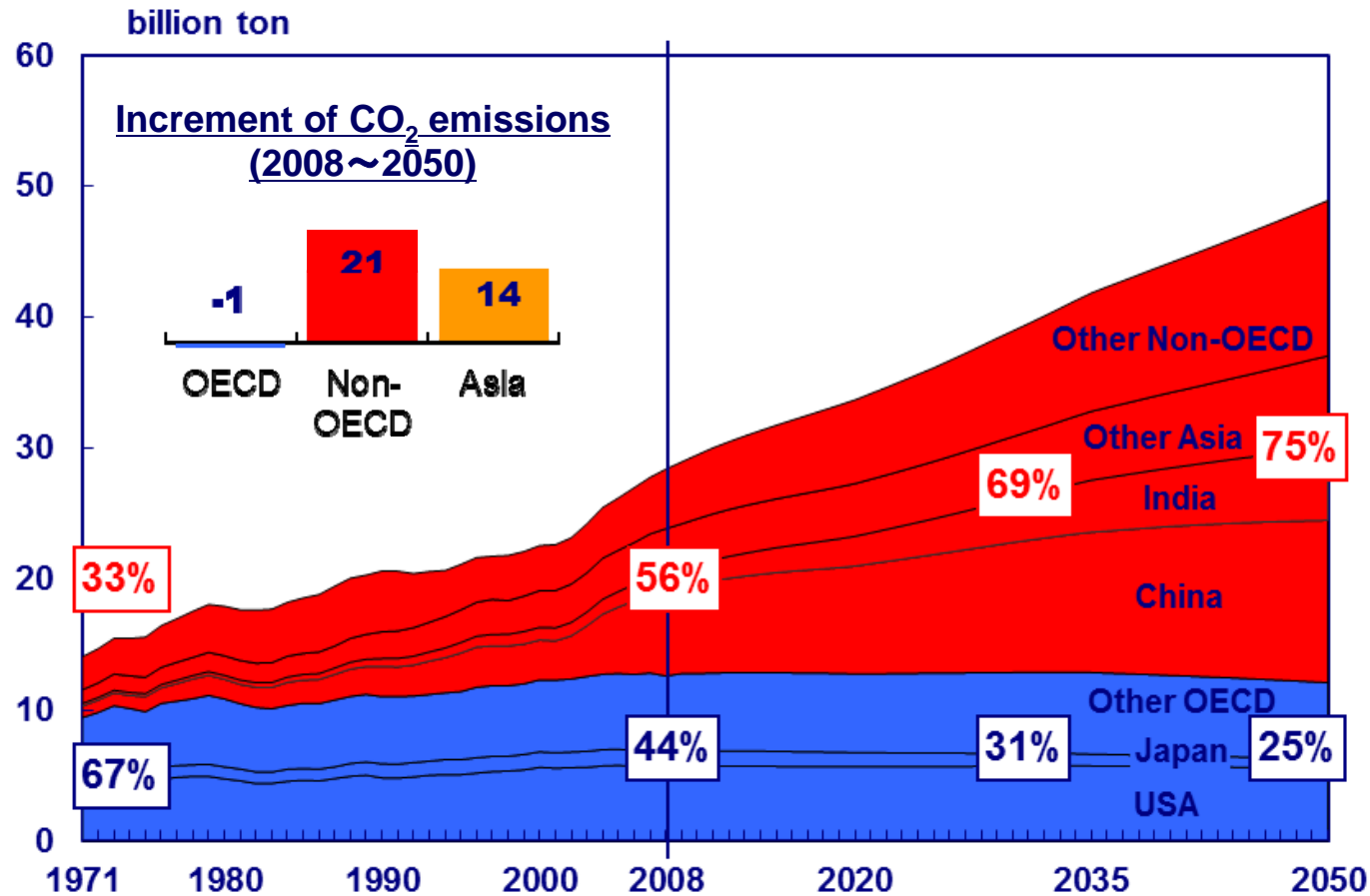
Power Generation Mix (World)



- In the Reference Scenario, the world power generation will grow from 20 PWh in 2008 to 50 PWh in 2050. In the Tech. Adv. scenario, the power generation in 2050 will reach 38 PWh – lower than the Reference Scenario due to energy conservation.
- The share of non-fossil power generation (including renewable and nuclear) will account for 31% in Reference and 59% in Tech. Adv. Scenario by 2050.

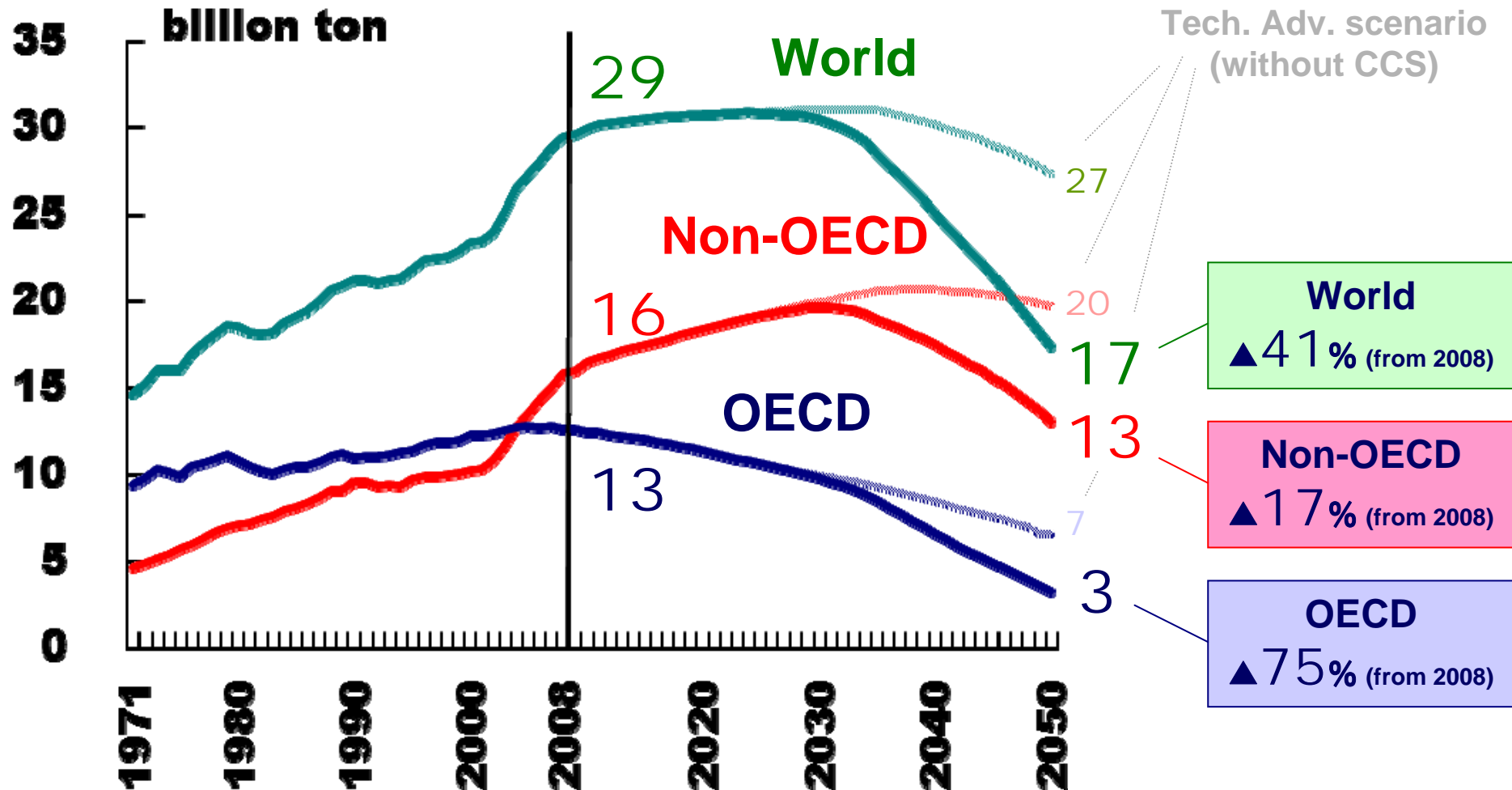
CO₂ Emissions (World)

Reference



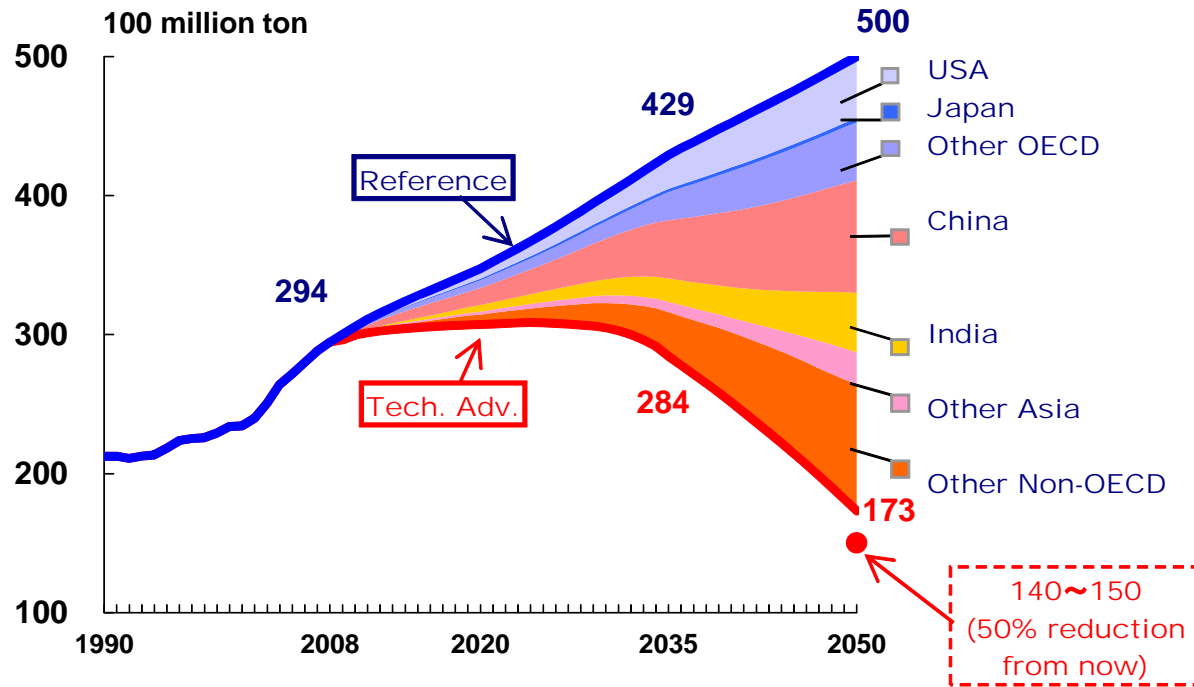
- The world CO₂ emissions will increase from 29.4 Gt in 2008 to 50.0 Gt in 2050, exhibiting a 1.7-fold increase. Emissions in OECD will decline from 12.6 Gt in 2008 to 12.1 Gt in 2050, while that in Non-OECD will expand from 15.8 Gt in 2008 to 36.8 Gt in 2050.
- The share of OECD in the world CO₂ emissions is projected to shrink from 44% in 2008 to 25% in 2050.

CO₂ Emissions (Tech. Adv. Scenario)



■ In the Tech. Adv. Scenario, CO₂ emissions of OECD in 2050 will decrease by 75% from 2008, and that of Non-OECD will decrease by 17% from 2008. This will eventually lead to the decline of world CO₂ emissions in 2050 by 41% from 2008. Without CCS, world CO₂ emissions will **102** edge down by only 7%.

CO₂ Emissions Reduction Potential by Region (World)

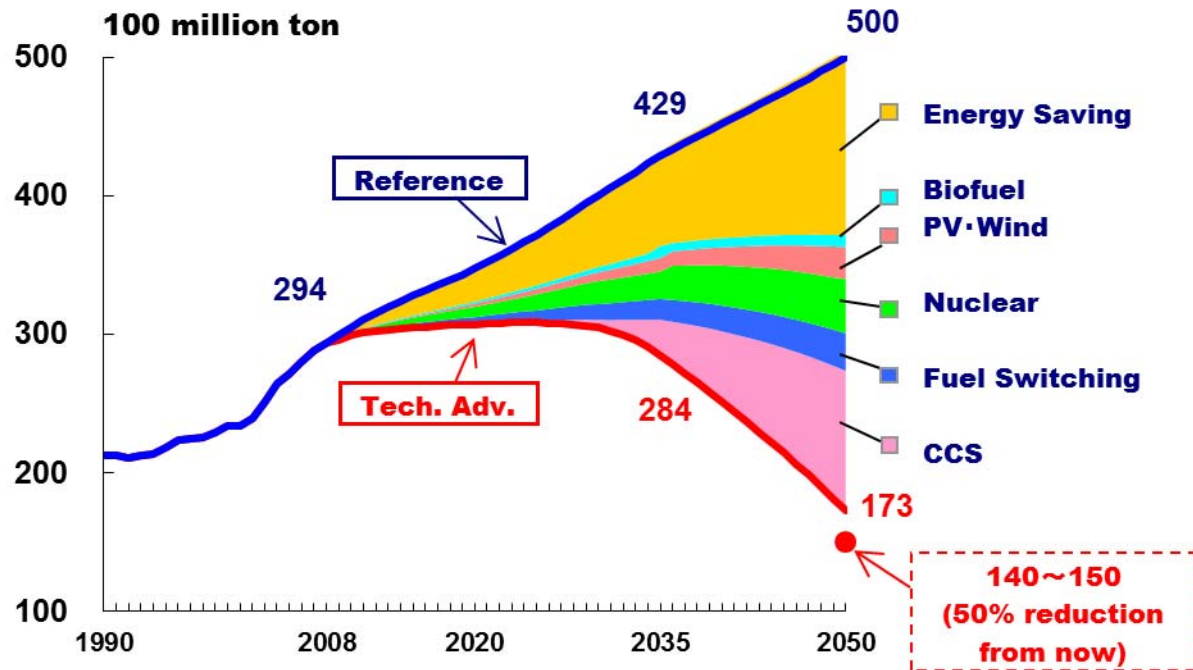


CO₂ emissions reduction in 2050

	100 mil. ton	Share
USA	44	14%
Japan	3	1%
Other OECD	42	13%
China	81	25%
India	43	13%
Other Asia	23	7%
Other Non-OECD	91	28%
OECD	89	27%
Non-OECD	238	73%
Developing Asia	147	45%
World	327	100%

- Non-OECD will account for 73% of the world CO₂ emissions reduction potential in 2050. This suggests that reinforcement of energy and environmental measures in developing countries would be important toward the global efforts to CO₂ emissions reduction.

CO₂ Emissions Reduction Potential by Technology (World)

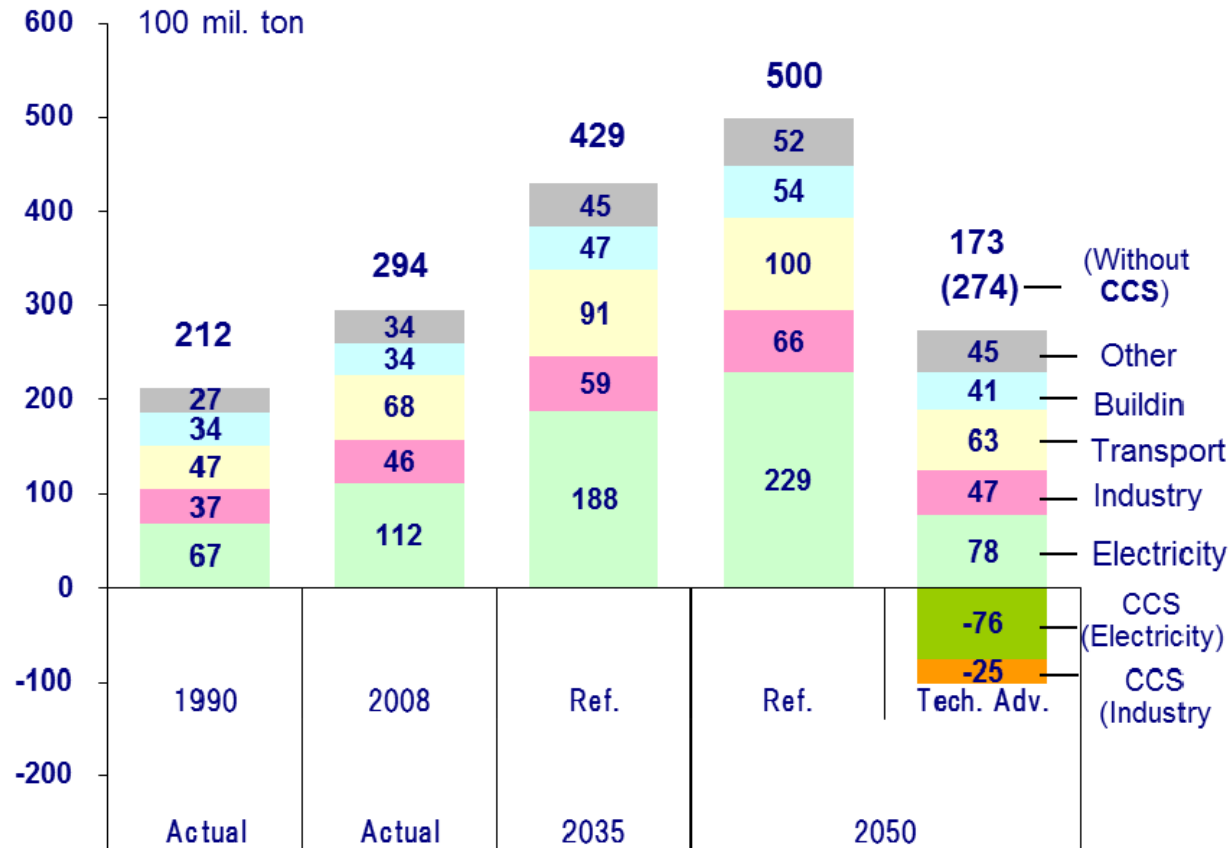


CO₂ emissions reduction in 2050

	100 mil. ton	Share
Energy Saving	131	40%
Biofuel	9	3%
PV-Wind	23	7%
Nuclear	39	12%
Fuel Switching	27	8%
CCS	99	30%
Total	327	100%

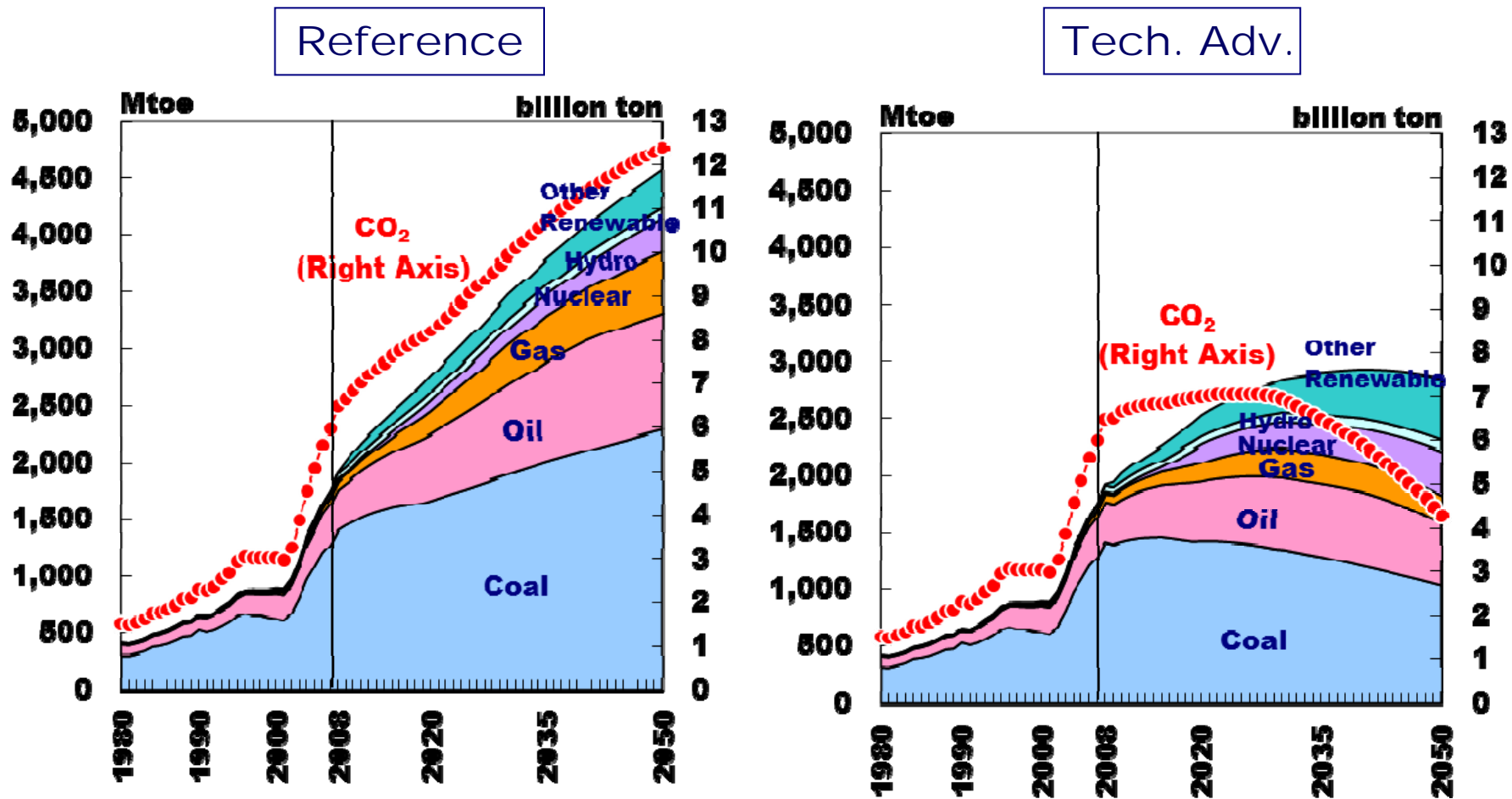
- Energy saving technology principally contributes to the world CO₂ reduction in 2050. Fuel switching and CCS will substantially mitigate global emissions as well.
- In order to halving world CO₂ emissions, further political and technological measures are required, such as progressive R&D, and development of low-carbon-emitting cities.

CO₂ Emissions (World: by Sector)



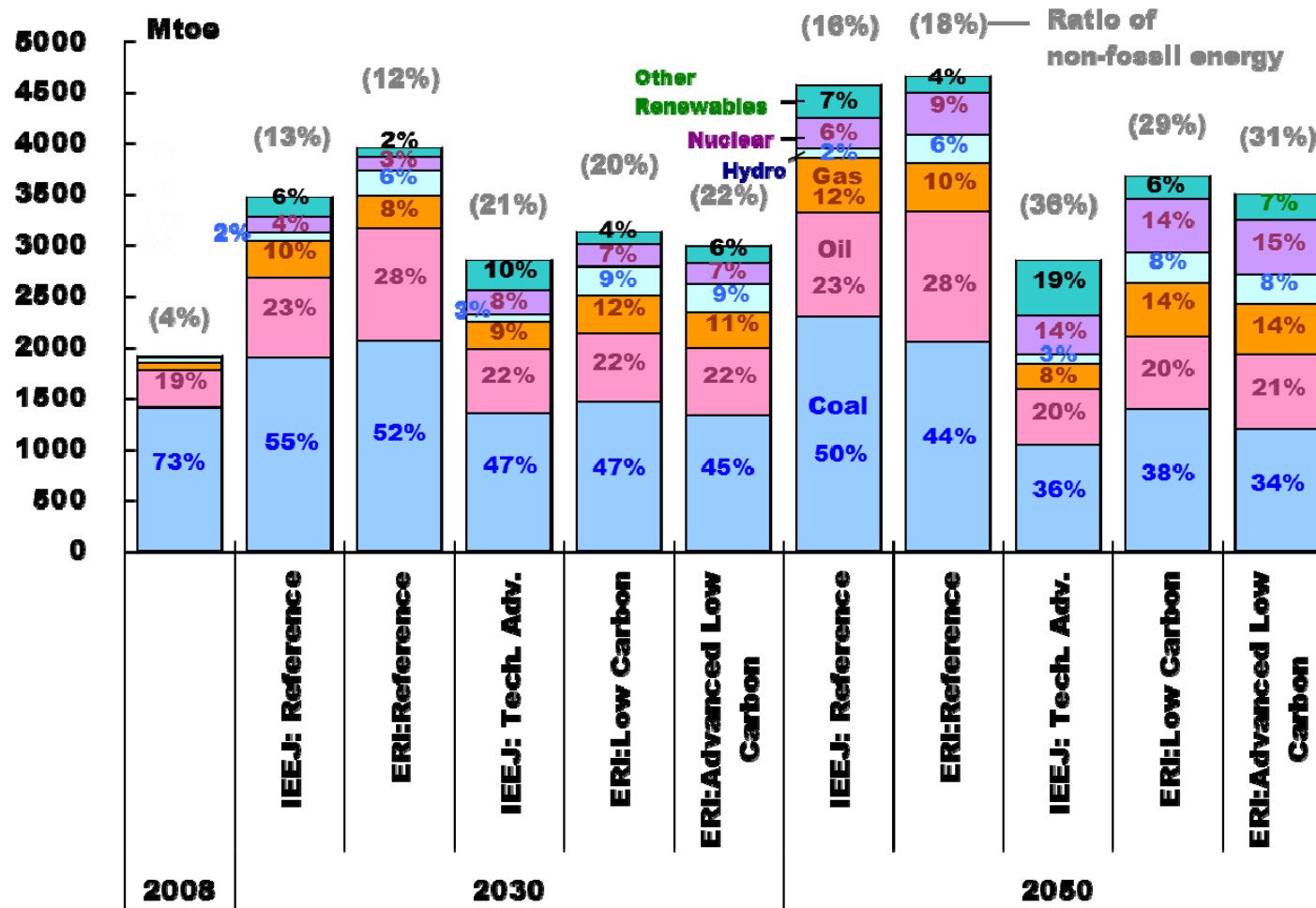
In the Tech. Adv. scenario, CO₂ emissions from the power sector will shrink by 98% from 2008 (without CCS, by 30% decline), industry, by 51% decline (without CCS, by 2% increase), transport, by 7% decline, and building, by 19% increase.

Primary Energy Demand and CO₂ Emissions in China



- In the Reference Scenario, the share of coal in China's primary energy mix will decrease from 73% in 2008 to 50% in 2050; that will go down further to 36% in the Tech. Adv. Scenario. The ratio of non-fossil energy sources in 2050 will amount to 16% in the Reference Scenario and 36% in the Tech. Adv. Scenario, increasing from 4% in 2008.
- CO₂ emissions in 2050 will reach 12.4 Gt in the Reference Scenario and 4.3 Gt in the Tech. Adv. Scenario from 6.5 Gt in 2008.

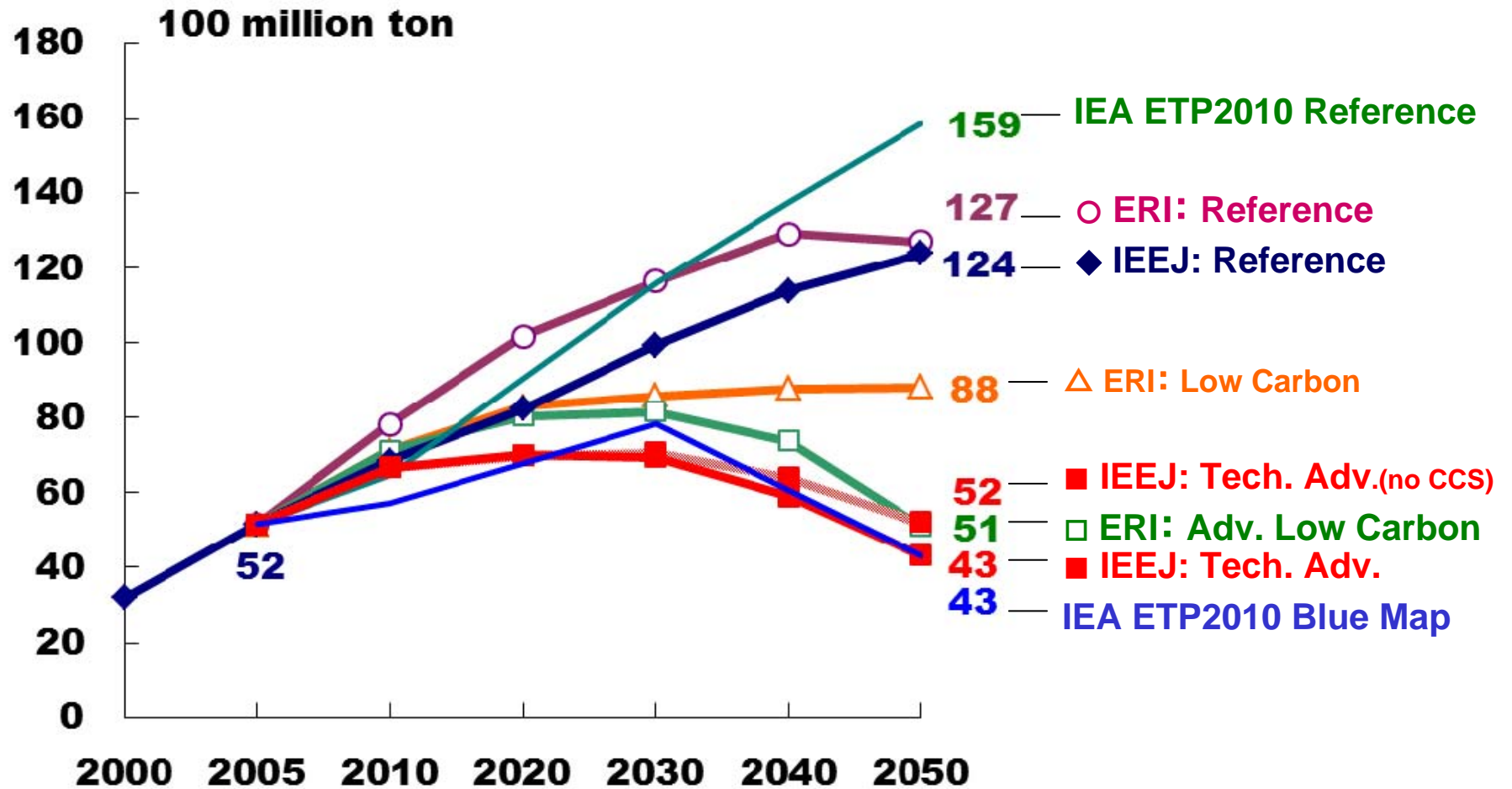
Comparison with ERI* study (Primary Energy Demand)



* Energy Research Institute(ERI), National Development and Reform Commission, China (2009). “China’s Low-Carbon Development Path through 2050 – Scenario Analysis of Energy Demand and Supply and CO₂ Emissions”

IEEJ’s Tech. Adv. Scenario estimates more extensive deployment of non-fossil fuel in 2050, the share of which is 36%, compared with ERI outlook’s Low Carbon Scenario at 29% and at 31% in the Advanced Low Carbon Scenario.

Comparison with ERI* study (CO₂ emissions)



* Energy Research Institute(ERI), National Development and Reform Commission, China (2009). "China's Low-Carbon Development Path through 2050 – Scenario Analysis of Energy Demand and Supply and CO₂ Emissions"

IEEJ's Tech. Adv. Scenario, ERI's Adv. Low Carbon scenario, and IEA's ETP2010 Blue Map scenario estimate almost similar CO₂ mitigation potential in 2050.

Summary : Energy Outlook for 2050

- In order to halve the world CO₂ emissions through 2050, further efforts are necessary to develop and deploy innovative technologies through 2050.
- Particularly energy saving and de-carbonization of power generation is expected to play crucial roles for massive reduction of the world CO₂ emissions both in OECD and Non-OECD countries.
- Since CO₂ mitigation potential in developing Asia, including China and India, will account for almost half of that of the world, implementation of energy and environmental measures in this region is the most important toward the global efforts on CO₂ emissions reduction.
- Although fossil fuel demand will peak around 2035 in the Tech. Adv. Scenario, it will account for the dominant share in total primary energy mix in 2050, suggesting the importance of efficient use of fossil fuels and ensuring means toward stable energy supply.
- Natural gas demand will continue to increase through 2050, and it is essential to invest in exploration and development toward stable supply.

Implications

■Tackling Climate Change Issues through Technology Transfer

CO₂ emissions in Asian developing countries are expected to grow at a faster pace than the world average, while these countries generally face technological and financial constraints to curb the growth trends in CO₂ emissions. Establishment of regional cooperation framework in Asia may facilitate research and development in technology between developed and developing countries, and at the same time developing Asian countries may need to continue the efforts to create appropriate investment conditions that can allow implementation of projects for developed countries to introduce advanced technologies toward energy efficiency improvement and lower CO₂ emissions. Such cooperation can offer cost effective options to reduce CO₂ emissions in Asia as a whole. For Japan, continued efforts are necessary to be made to advance on the technological development on energy conservation and environmental technologies, and at the same time, using these technologies, Japan may have a great role to support global efforts to reduce CO₂ emissions.

■ Ensuring Energy Supply Security

In Asia, ensuring a stable energy supply will become an important issue as oil demand grows sharply and the dependence on imports for oil supply rises further in the future. Countries in Asia would have to implement various measures to ensure stable energy supply. As a short-term measure, Asia may need to establish and strengthen emergency response systems as a countermeasure for oil supply disruptions; and as medium-to long-term measures, efforts are necessary to develop an international oil market that can respond flexibly to changes in supply and demand, as well as to enhance its market functions and ensure transparency. Additionally efforts need to be made to strengthen relations with countries in the Middle East since Asia's reliance to the region as oil import source may grow in the future. Aside from these, Asian countries may need to continue implementing domestic measures for energy efficiency improvement and energy source diversifications. On the other hand, excessive pursuit of self-interest by a single country could undermine the energy security of the entire region. As Asian countries share a common interest as major energy consuming nations, it is important that they deal with the issue as a problem concerning the entire region.

■ Challenges towards best energy mix

Ensuring a stable supply of fossil fuels and their effective use

Fossil fuels are finite, and their consumption is accompanied by greenhouse gas emissions. Nevertheless, when economic viability and lead time for the commercialization of innovative technology are considered, it is important to strive toward the effective utilization of fossil energy. In addition to ensuring a stable supply of fossil fuels, using them in a clean and highly efficient fashion is essential from the perspectives of energy security, and environmental reasons.

[Oil]

A substantial expansion in oil production cannot be expected in the Asian region, and its dependence on imports for oil supply will rise to 81% in 2035. Covering some 50% of Asia's oil consumption increase will be the OPEC members in the Middle East that are rich with oil resources and can offer oil in a more cost competitive way than other oil-exporting countries. Steady investment in oil production capacity expansion to meet the rise in demand will be the key to stable supply of the international oil market. On the demand side, an important issue will be to strive for the effective use of oil through the introduction of fuel efficient and alternative energy vehicles, whose full-fledged practical use is expected over the medium to long term.

[Natural gas]

Natural gas production in the Asian region will peak while gas demand will increase due to fuel switching in the electricity generation and residential and commercial sectors. Therefore, demand will expand for LNG and natural gas transported from Russia and central Asia via pipelines. As with oil, continued investment toward the expansion of production and transportation capacity will be the key to meet the projected increase in natural gas demand.

[Coal]

Coal demand will increase mainly for electricity generation due to abundant resource endowment and cost competitiveness against the other energy sources. As measures to lower CO₂ emissions from coal combustion, the development and introduction of high-efficiency coal-fired power generation, clean coal technology and CCS are urgently required.

Nuclear power:

Nuclear energy will play a major role in Asia, where ensuring energy security will become increasingly important to meet fast-growing energy demand. Nuclear power, which is also important for helping to tackle global warming, should be increasingly introduced as a stable energy supply source.

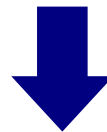
Technology development of renewable energy:

Wind power and photovoltaic power generation are an important option among measures to mitigate global warming. In addition, along with automobiles' fuel efficiency improvement, the introduction of bio-fuels is expected as a means to help reduce CO₂ emissions in the transport sector. It is necessary to enhance systems for effective and efficient promotion of renewable energy diffusion and introduce supporting policies to further expand the use of renewable energy.

It will also become important to consider the time frame with regard to technology development that contributes to ensuring energy security and enhancing measures against global warming. Progress in technology development and change in the energy supply and demand structure will be limited by 2020, while current technology development and supply-demand structural change are expected to take place around 2030. Therefore, technology strategies with a long-term outlook beyond 2030 are required.

Conclusion

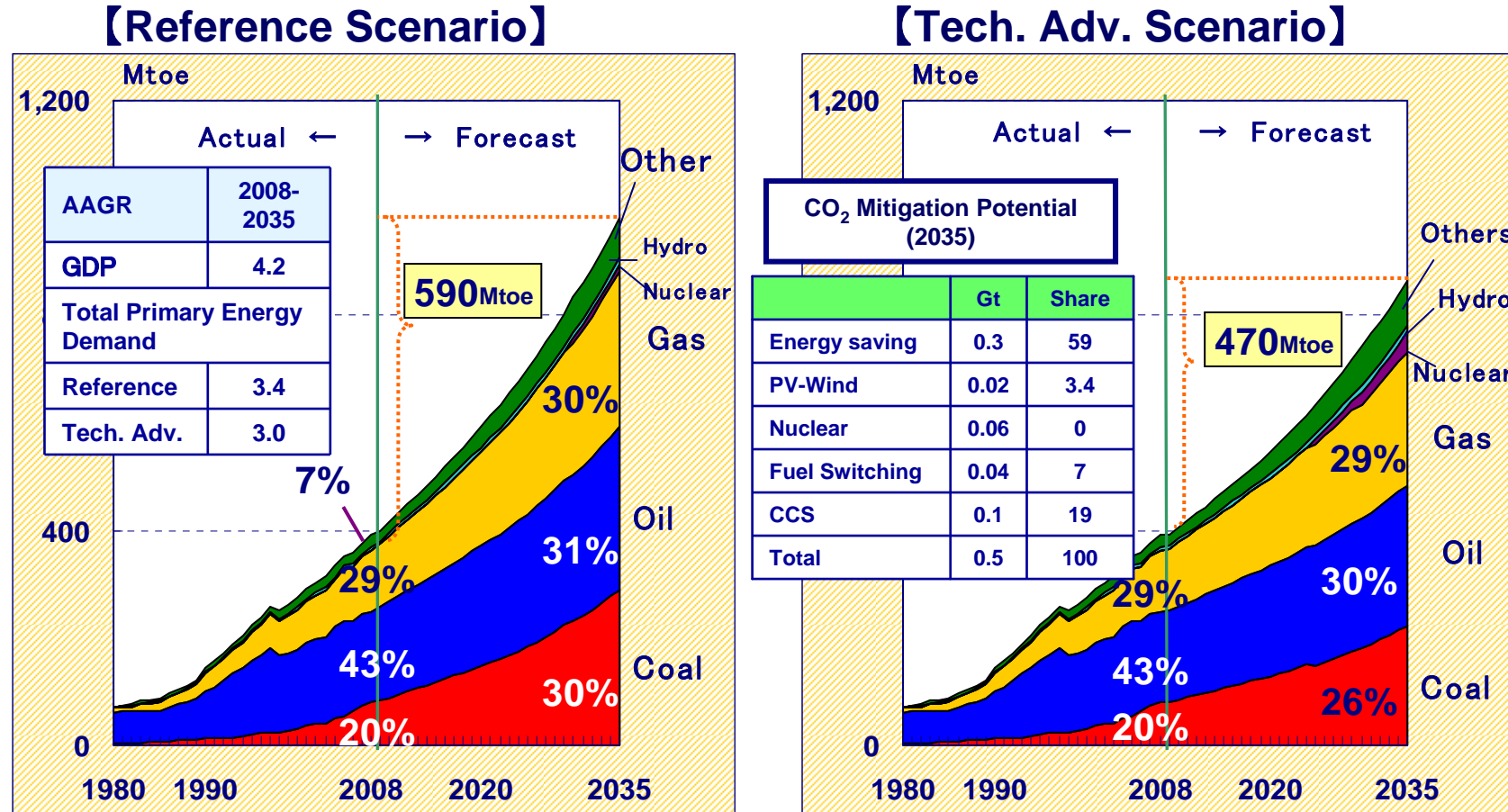
In order to simultaneously achieve “3E objectives”— Energy (stable energy supply), Economy (economic development) and Environment (environmental conservation)— in Asia, countries in the region should enhance their efforts to attain the best energy mix by diversifying energy supply sources and promoting a shift to low-carbon energy sources through energy conservation and fuel switching.



Japan, which has technological, economic and institutional advantages over other Asian countries, has a great role to play in this respect. In particular, Japan is competitive in energy-saving and environmental conservation technologies that play a central role in achieving the 3E objectives simultaneously. Further development and utilization of these energy-saving and environmental conservation technologies should be a key option of Japan’s international energy strategy. In the future, it will be important for Japan to utilize these advanced technologies to step up efforts to achieve the 3E objectives simultaneously and accomplish its sustainable economic growth as a leading technology-oriented nation.

<Reference Material>

Primary Energy Demand (ASEAN)

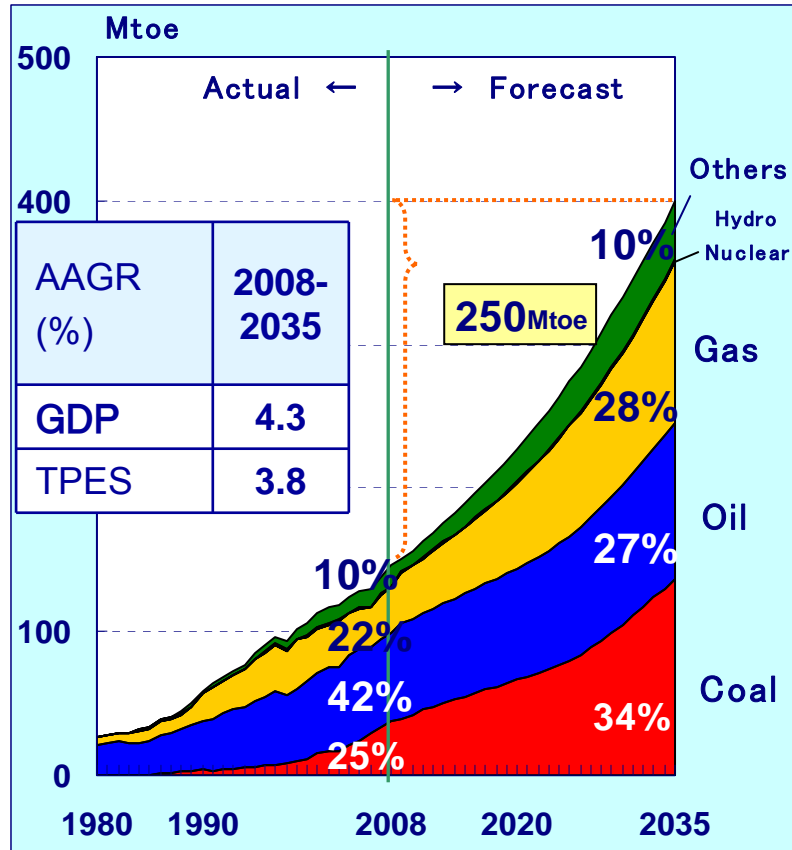


ASEAN countries have achieved economic growth reflecting on abundant labor force and exporting manufacturing product to international market. These factors have led to increase its energy demand. Electricity demand, in particular, represents fast growth and a couple of nuclear power plants is projected to be installed for securing electricity supply.

Primary Energy Demand (Indonesia, and Malaysia)

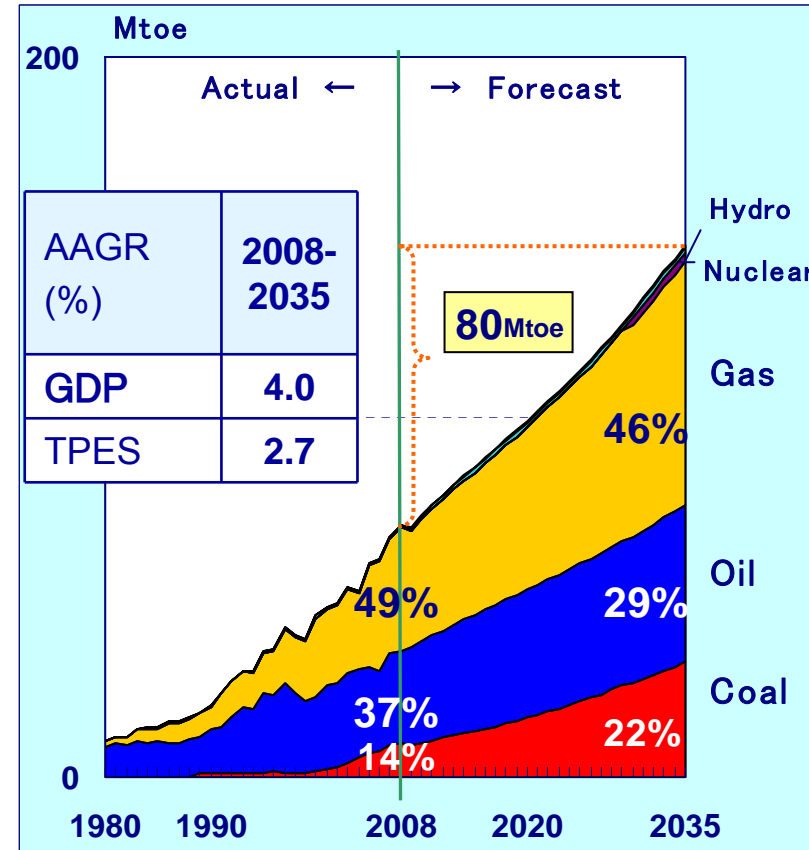
【Indonesia】

(Reference)



【Malaysia】

(Reference)



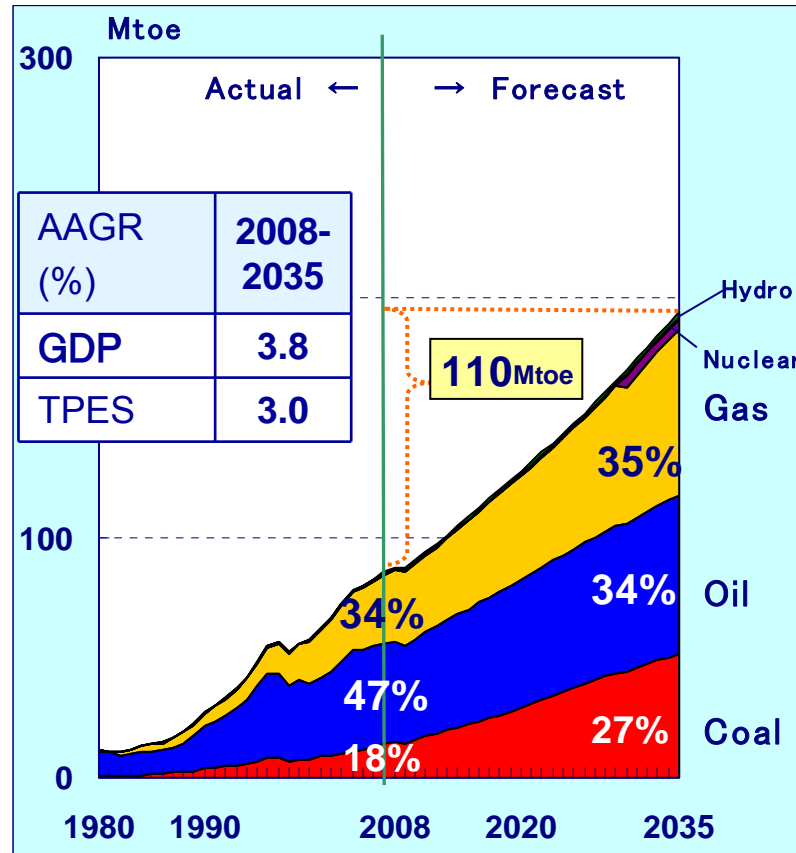
Indonesia: Major target of energy policy is composed of securing energy supply, exporting domestic energy resources at high value, managing domestic energy reserves, and providing affordable energy to low-income people.

Malaysia: Political priority is emphasized on ensuring affordable energy supply and sustainable economic growth. Basic target is fuel diversification, energy efficiency and environmental protection.

Primary Energy Demand (Thailand, and Vietnam)

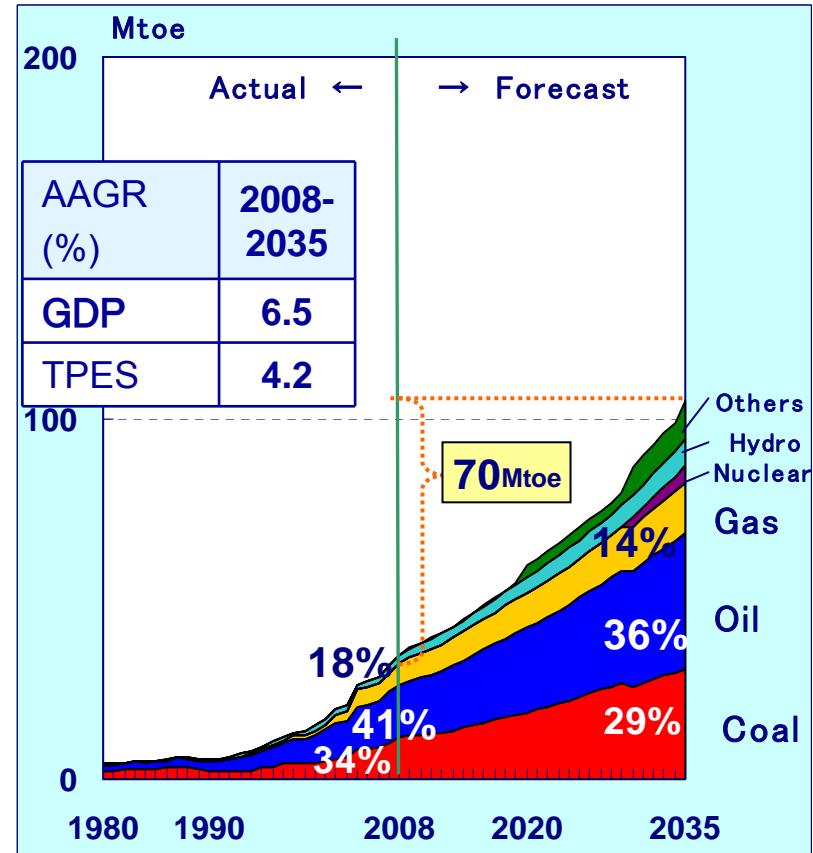
【Thailand】

(Reference)



【Vietnam】

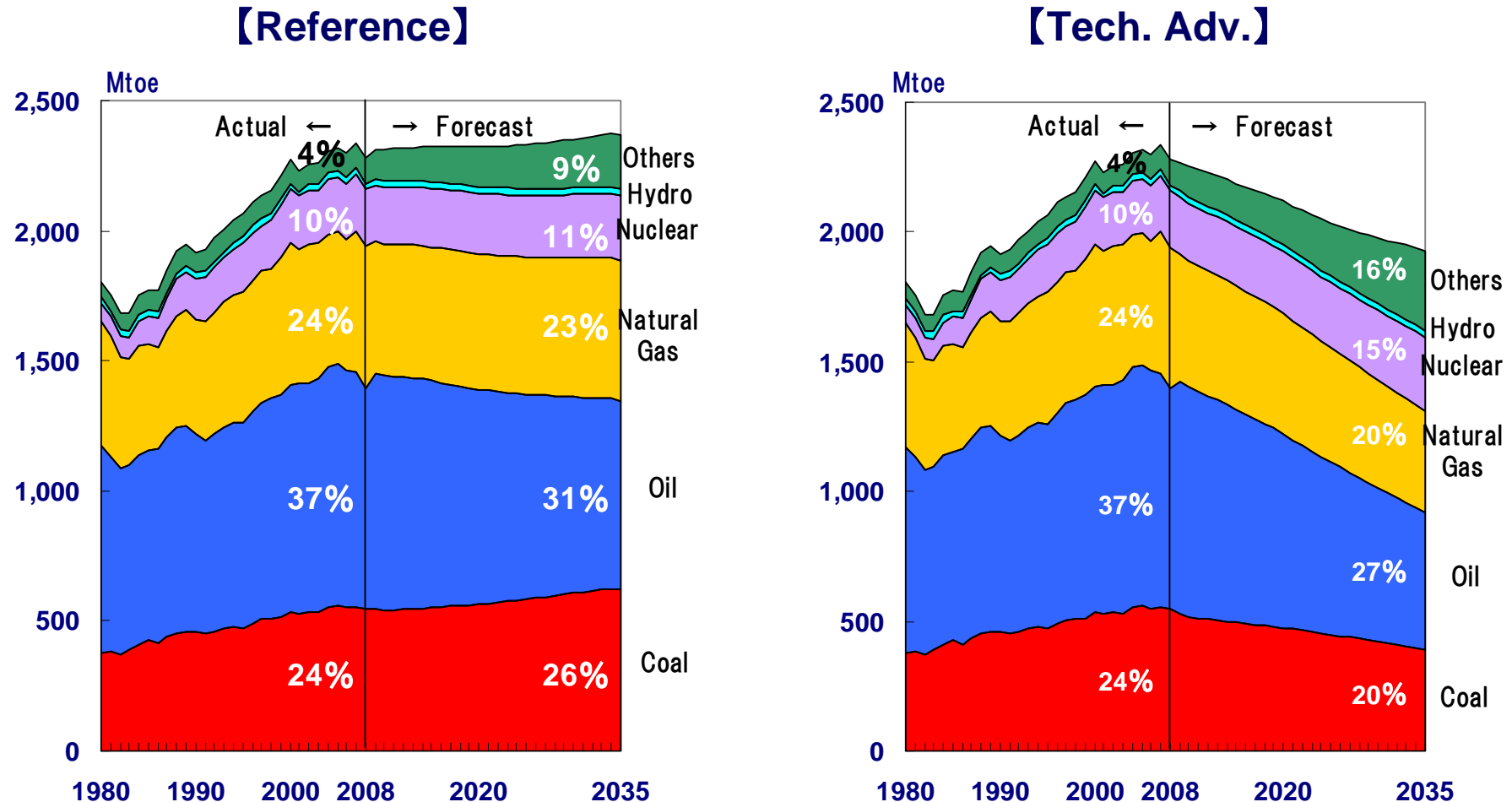
(Reference)



Thailand: Energy policy emphasis is placed on energy supply security, appropriate energy price, alternative fuel, energy efficiency, and environmental protection. The government focuses on the CDM project.

Vietnam: The government aims to promote foreign investment in the upstream sector in order to ramp up domestic oil production, and increase oil export for expanding foreign currency revenues.

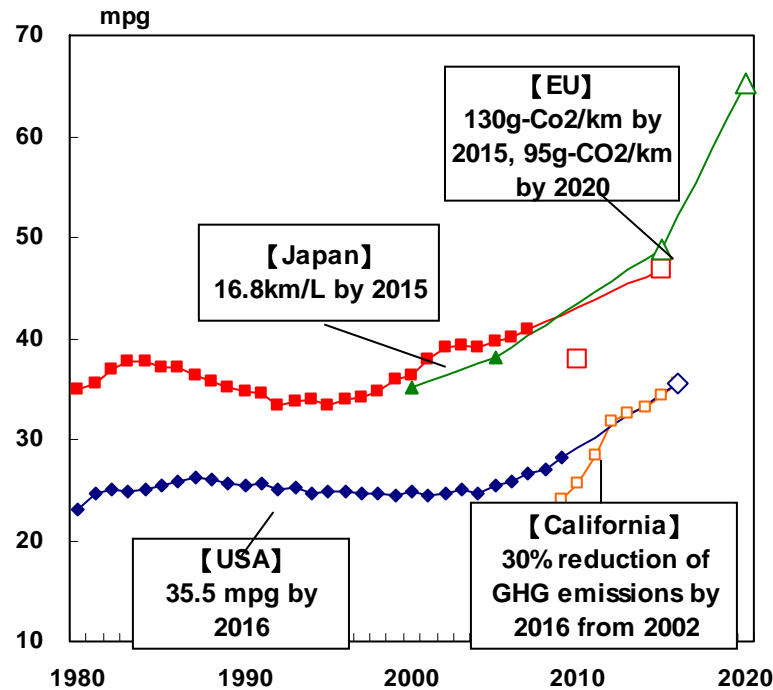
Primary Energy Demand in the U.S.



- Oil demand will decrease due to the vehicles fuel efficiency improvement and deployment of bio-fuel. Oil demand will decline from 17.7 mb/d in 2008 to 15.1 mb/d in Reference and 10.9 mb/d in Tech. Adv by 2035.
- Renewables, particularly wind and bio-fuel, will considerably increase.

Gasoline Demand in U.S.

【 Fuel Efficiency Regulations 】

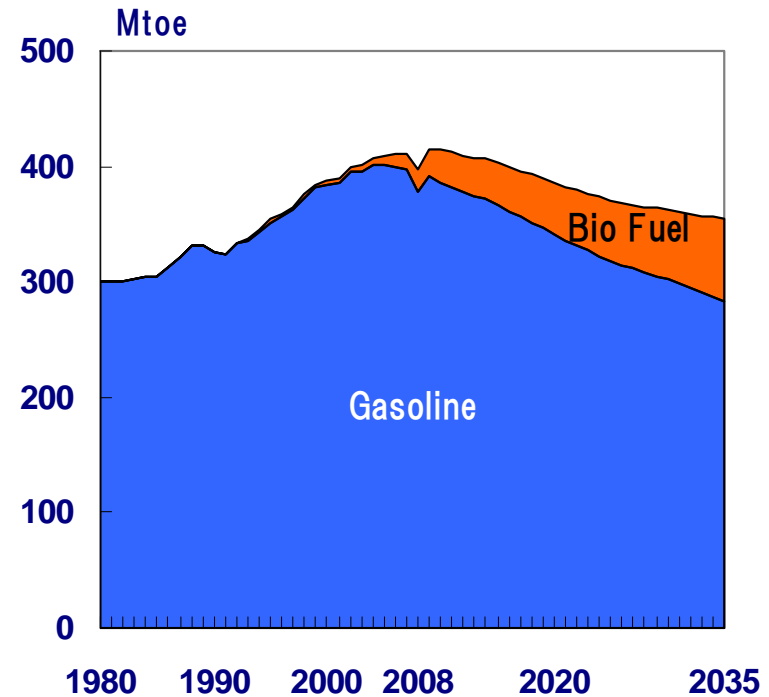


※outline characters on a colored background indicates fuel economy standard under consideration.

The government declared to raise CAFE standards to 35.5 mpg (15km/L) by 2016, almost equivalent to the standards in California.

【 Gasoline Demand in US 】

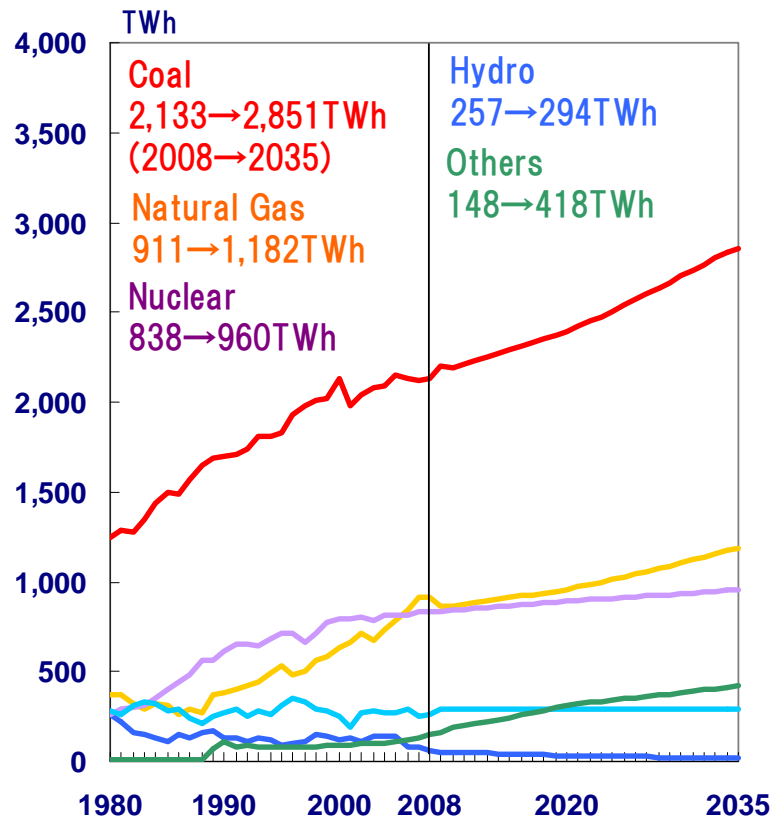
(Reference)



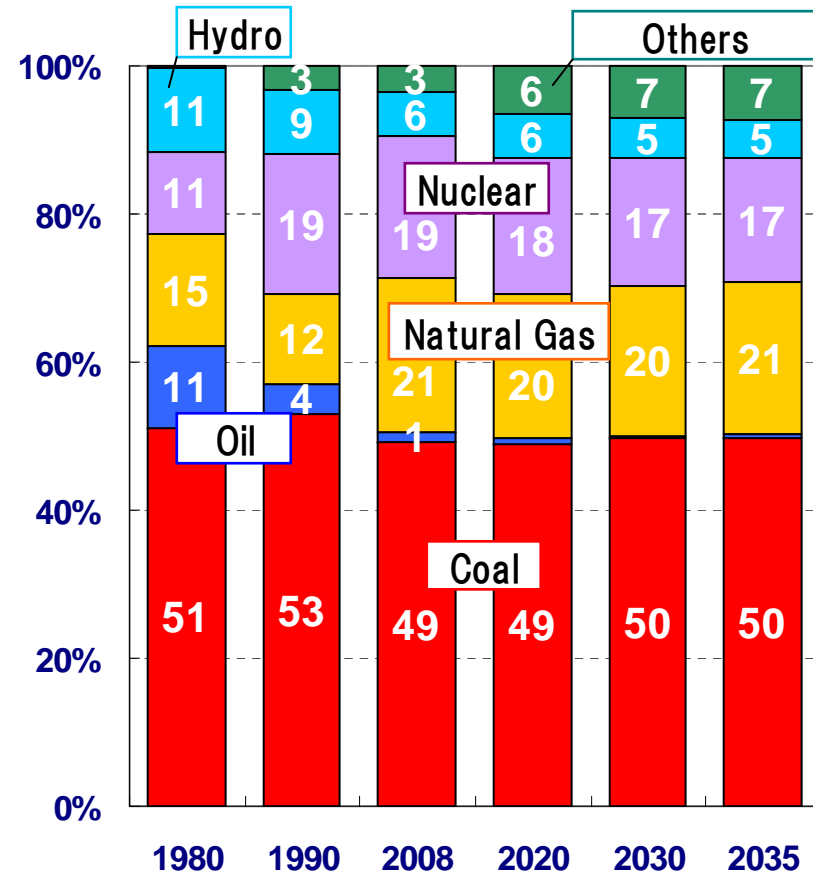
The US gasoline demand is forecast to decline reflecting on improved CAFE standards and growing share of bio-fuel.

Power Generation Mix in the U.S.

【Power Generation】 (Reference)

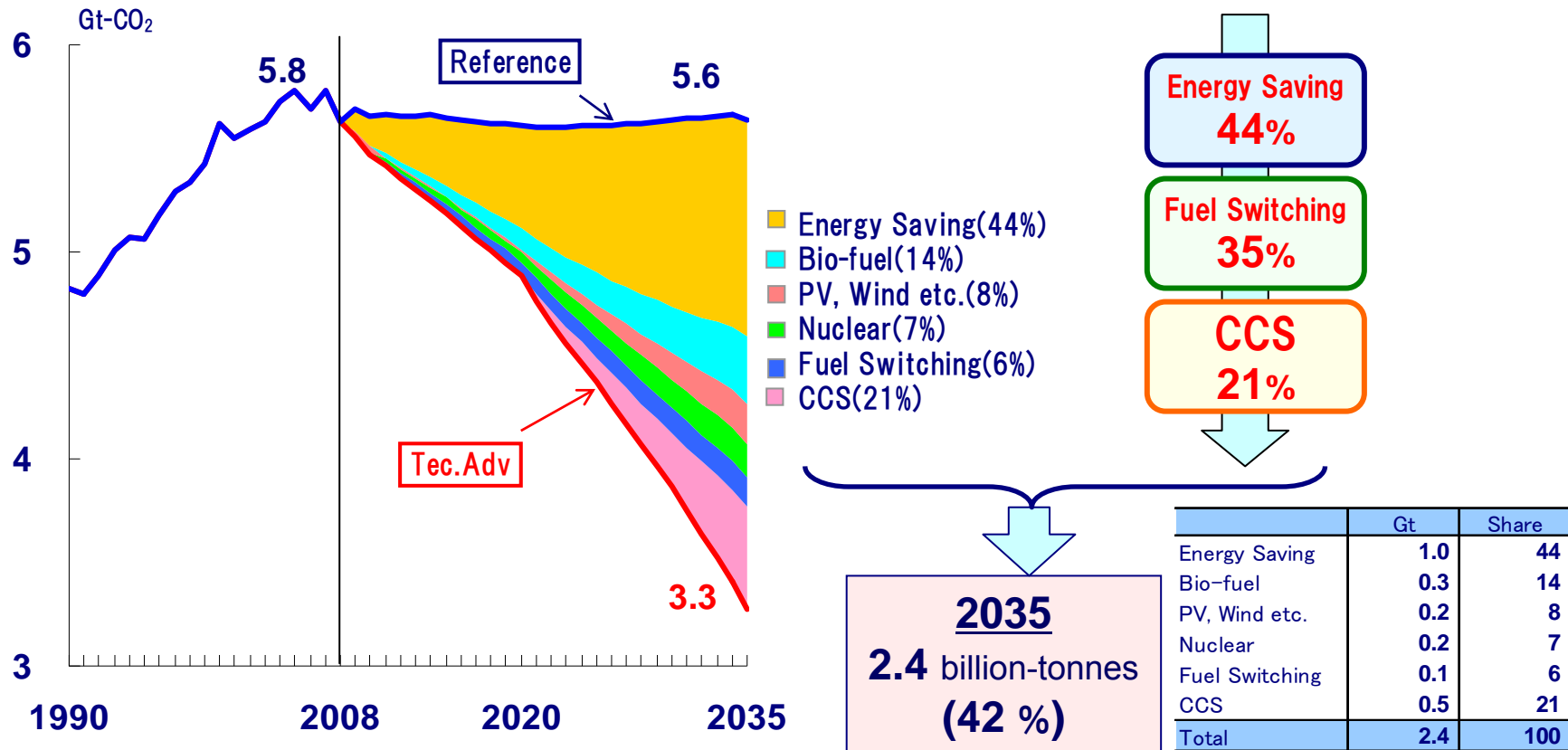


【Power Generation Mix】 (Reference)



- Coal-fired generation will account for 50% of total generation by 2035. To lower environmental burden, clean coal technology is expected to be widely applied.
- Clean Coal Power Initiative (CCPI) and Future Gen 2.0 will attempt to demonstrate the viability of “Clean Coal Technology” under the US. Government.

CO₂ Emissions Reduction in the U.S.



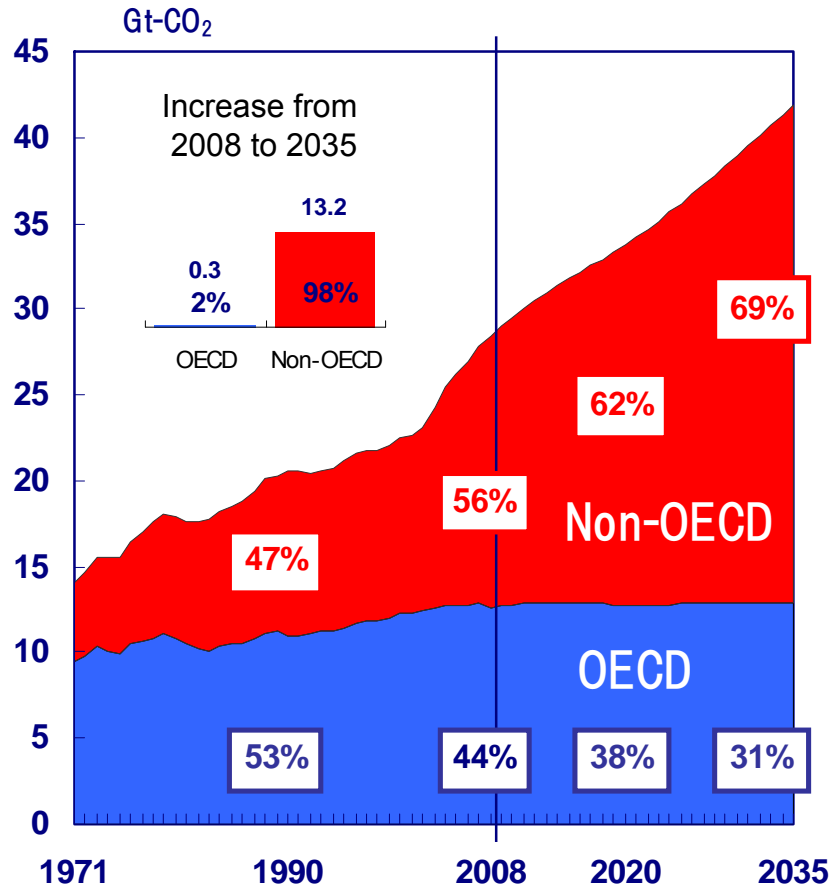
■CO₂ emissions in the Tech. Adv. Scenario will be 2.4 billion toe lower compared with the Reference Scenario.

■The CO₂ emissions in U.S. building sector is likely to grow continuously, suggesting that measures need to be implemented to improve energy efficiency and utilize low-carbon emission power generation technologies.

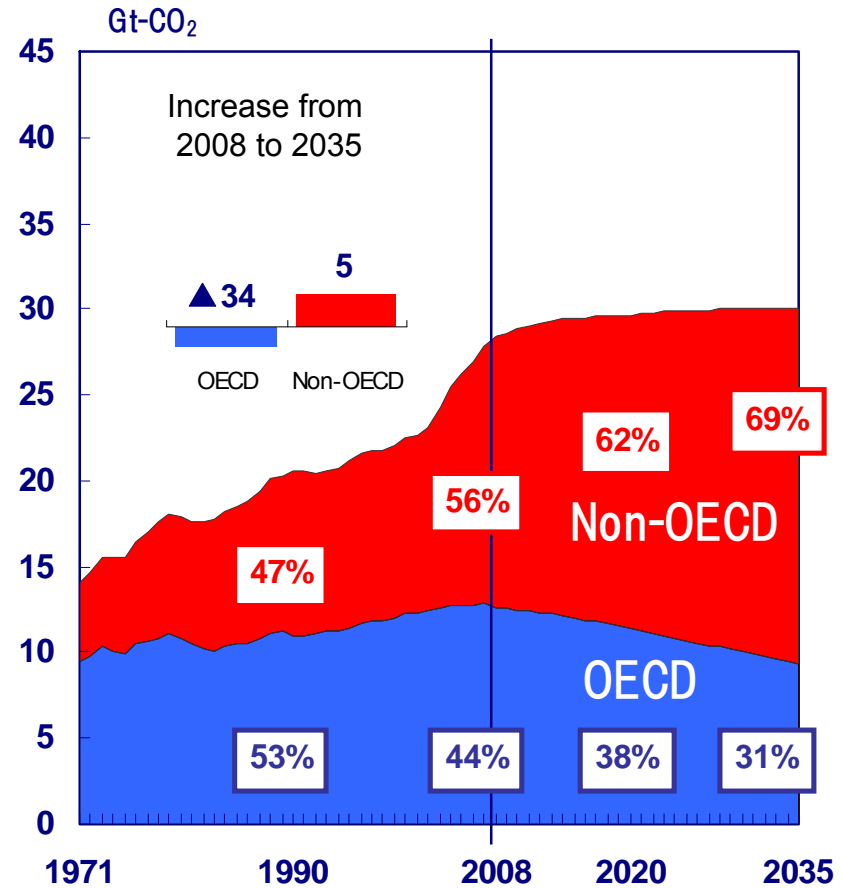
CO₂ emissions (OECD and Non-OECD)



Reference



Tech. Adv.

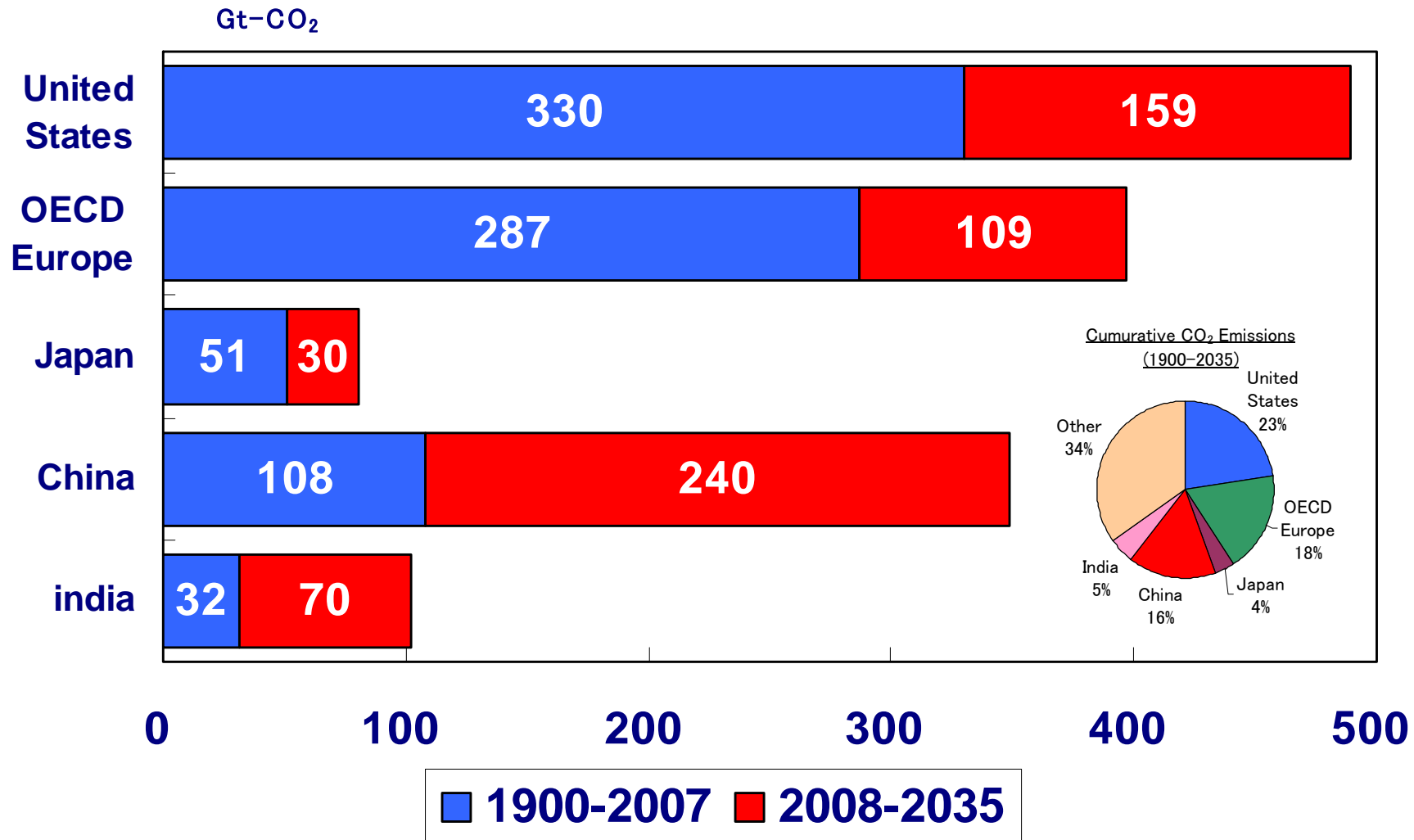


*It doesn't include emissions from International bunkers.

- In the Reference Scenario, Non-OECD will account for 98% of world total CO₂ emissions growth by 2035.
- In the Tech. Adv. Scenario, Non-OECD's CO₂ emissions will increase by 3.3 Gt-CO₂ (in contrast to Reference Scenario's increase by 13.2 Gt-CO₂) and that of OECD decrease by 3.7 Gt-CO₂ through 2035.

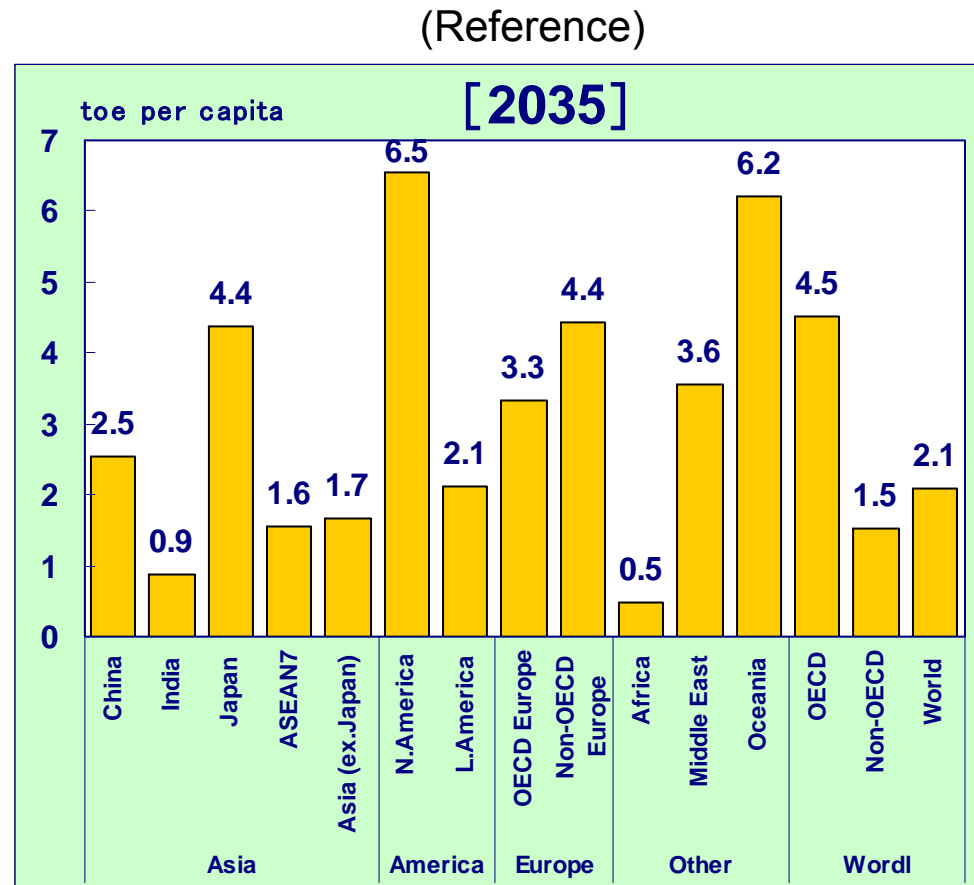
Cumulative CO₂ emissions (1900-2035)

(Reference Scenario)



Primary Energy Demand per Capita

	(toe per capita)		
	1980	2008	2035
China	0.4	1.4	2.5
India	0.1	0.4	0.9
Japan	3.0	3.9	4.4
Korea	1.1	4.7	6.2
Taiwan	1.6	4.5	5.5
Indonesia	0.2	0.6	1.4
Malaysia	0.7	2.6	4.0
Philippines	0.3	0.4	0.8
Thailand	0.2	1.3	2.6
Vietnam	0.1	0.4	1.0
N.America	7.9	7.6	6.5
OECD Europe	3.2	3.3	3.3
OECD	4.2	4.6	4.5
Non-OECD	0.7	1.0	1.5
World	1.6	1.8	2.1

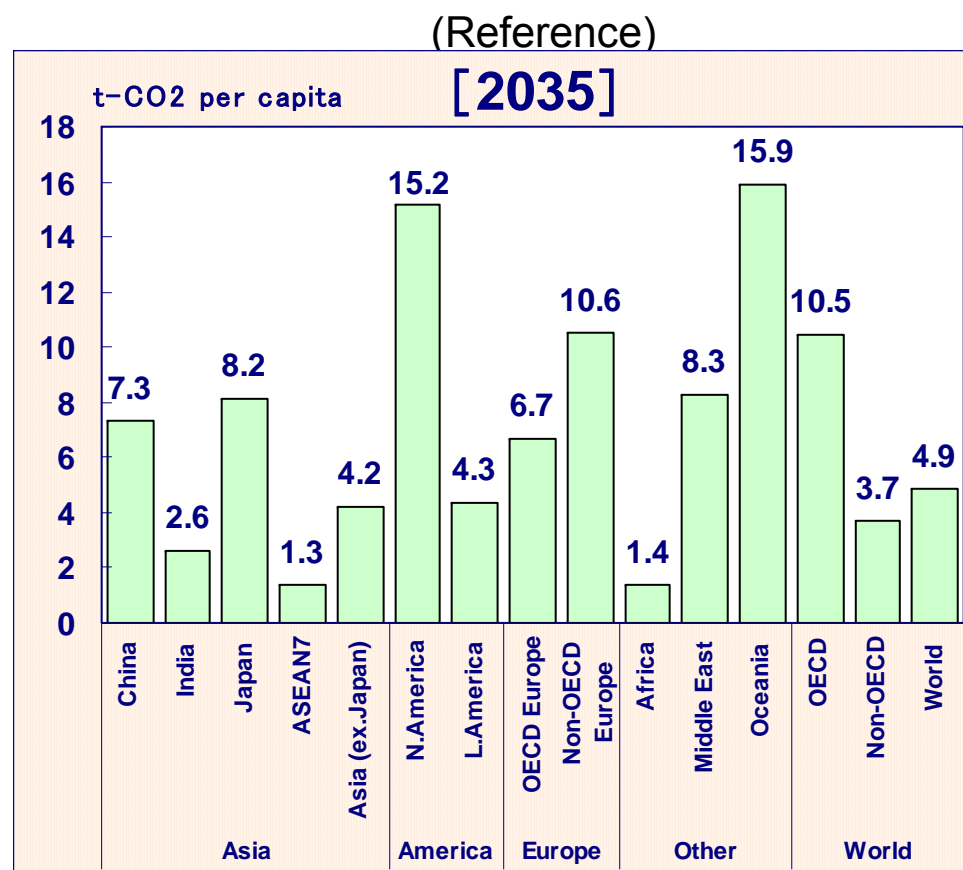


※ASEAN7:Indonesia, Malaysia, Thailand, Philippines, Vietnam, Singapore, and Brunei

- The world's energy demand per capita will increase with improvement in living standards. Meanwhile, per capita primary energy demand in China and India will still represent lower levels than the OECD average by 2035.

CO₂ Emissions per Capita

	(t-CO ₂ per capita)		
	1980	2008	2035
China	1.5	4.9	7.3
India	0.4	1.3	2.6
Japan	7.8	9.3	8.2
Korea	3.3	10.1	12.4
Taiwan	4.2	11.2	12.8
Indonesia	0.5	1.7	3.7
Malaysia	2.1	7.0	11.4
Philippines	0.7	0.8	2.1
Thailand	0.7	3.3	6.8
Vietnam	0.3	1.2	2.4
N.America	20.5	18.2	15.2
OECD Europe	8.8	7.2	6.7
OECD	11.3	10.9	10.5
Non-OECD	2.0	2.8	3.7
World	4.1	4.4	4.9

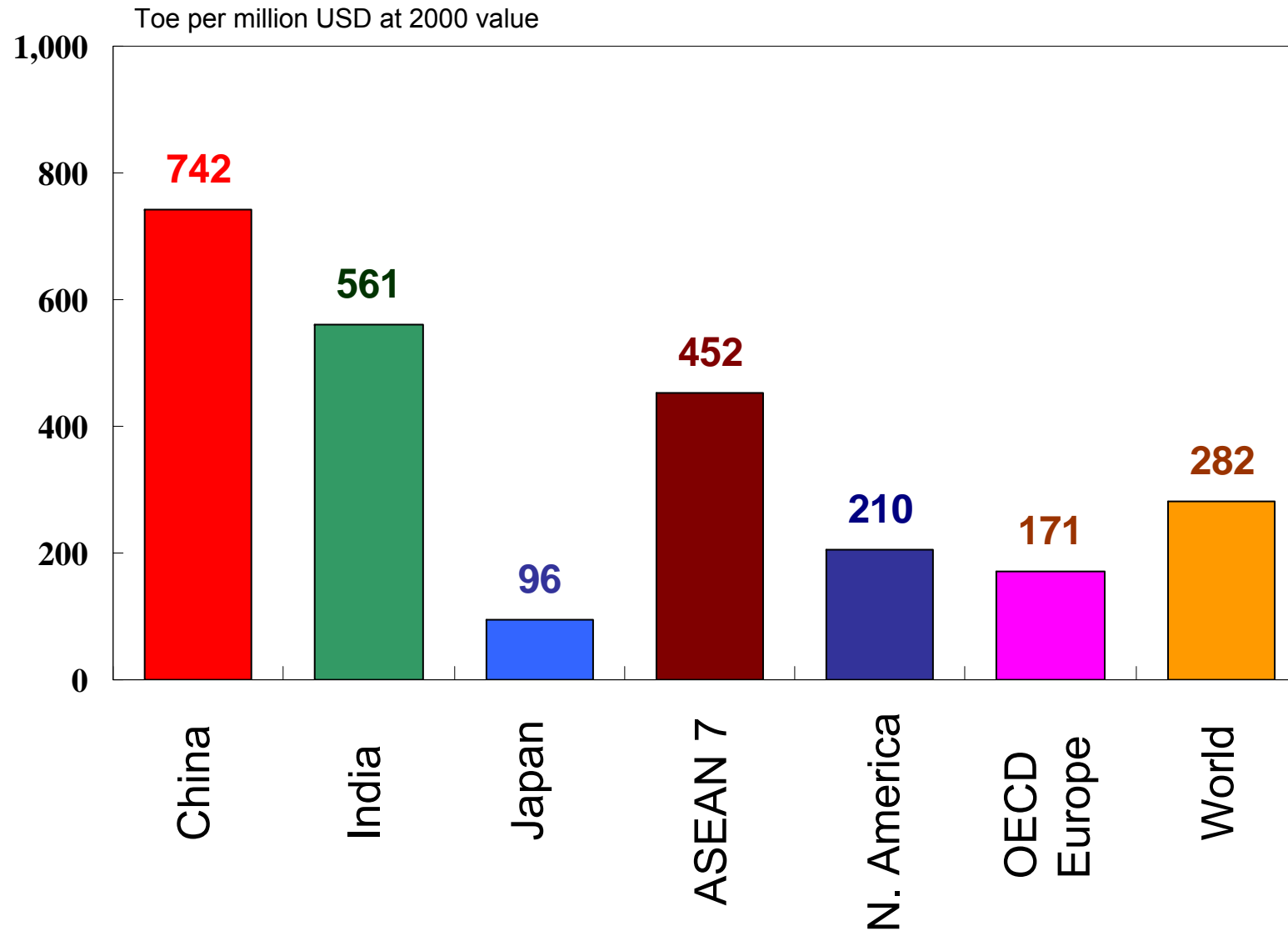


※ASEAN7: Indonesia, Malaysia, Thailand, Philippines, Vietnam, Singapore, and Brunei

- Per capita CO₂ emissions of Non-OECD will increase at a faster pace than population growth.
- CO₂ per capita in OECD will be on decreasing trend to 2035, because of energy efficiency improvement and expansion of non fossil fuels.

Primary Energy Demand per GDP(2008)

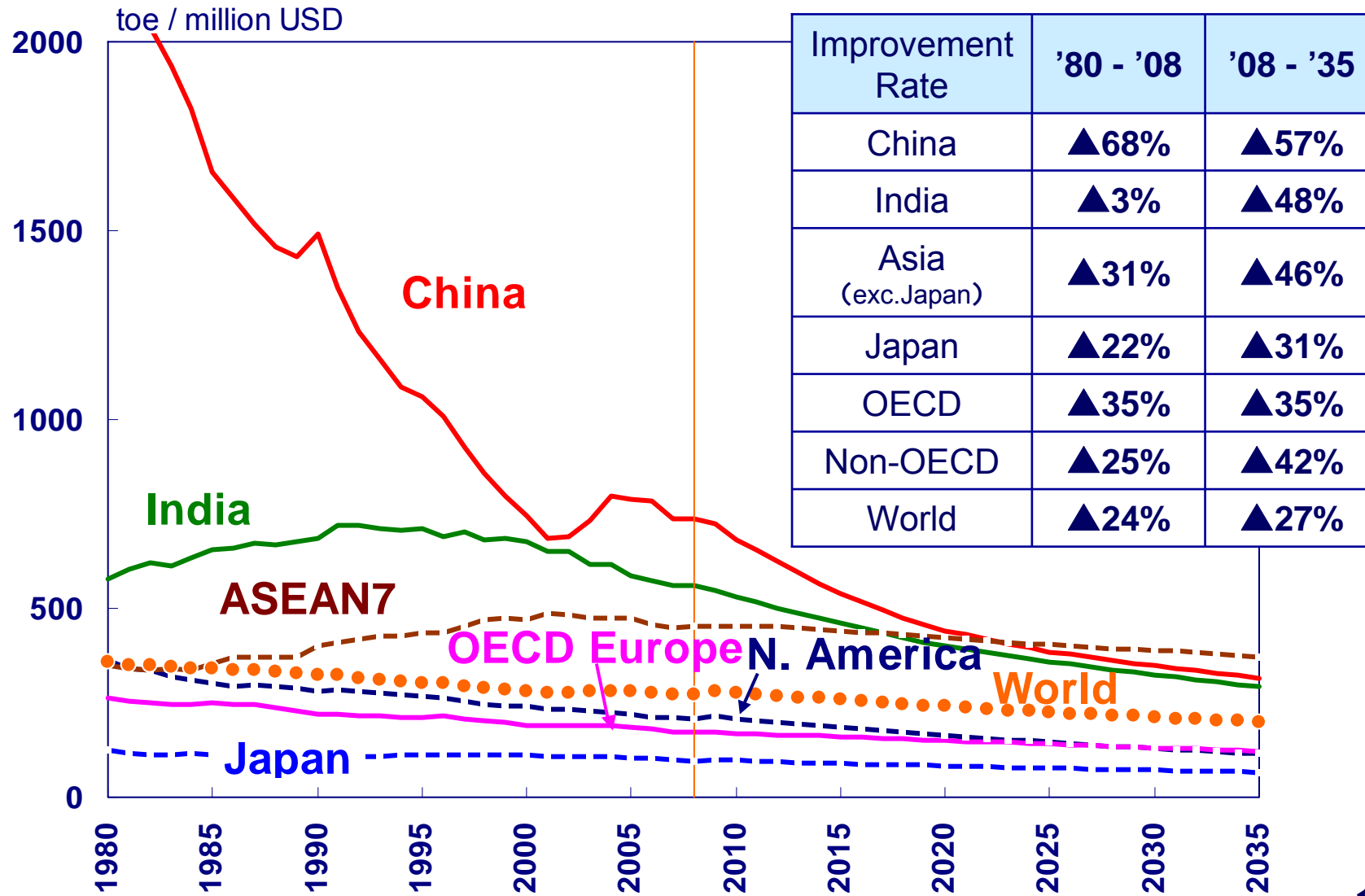
※ASEAN7:Indonesia, Malaysia, Thailand, Philippines, Vietnam, Singapore, and Brunei



Primary Energy Demand per GDP

(Reference)

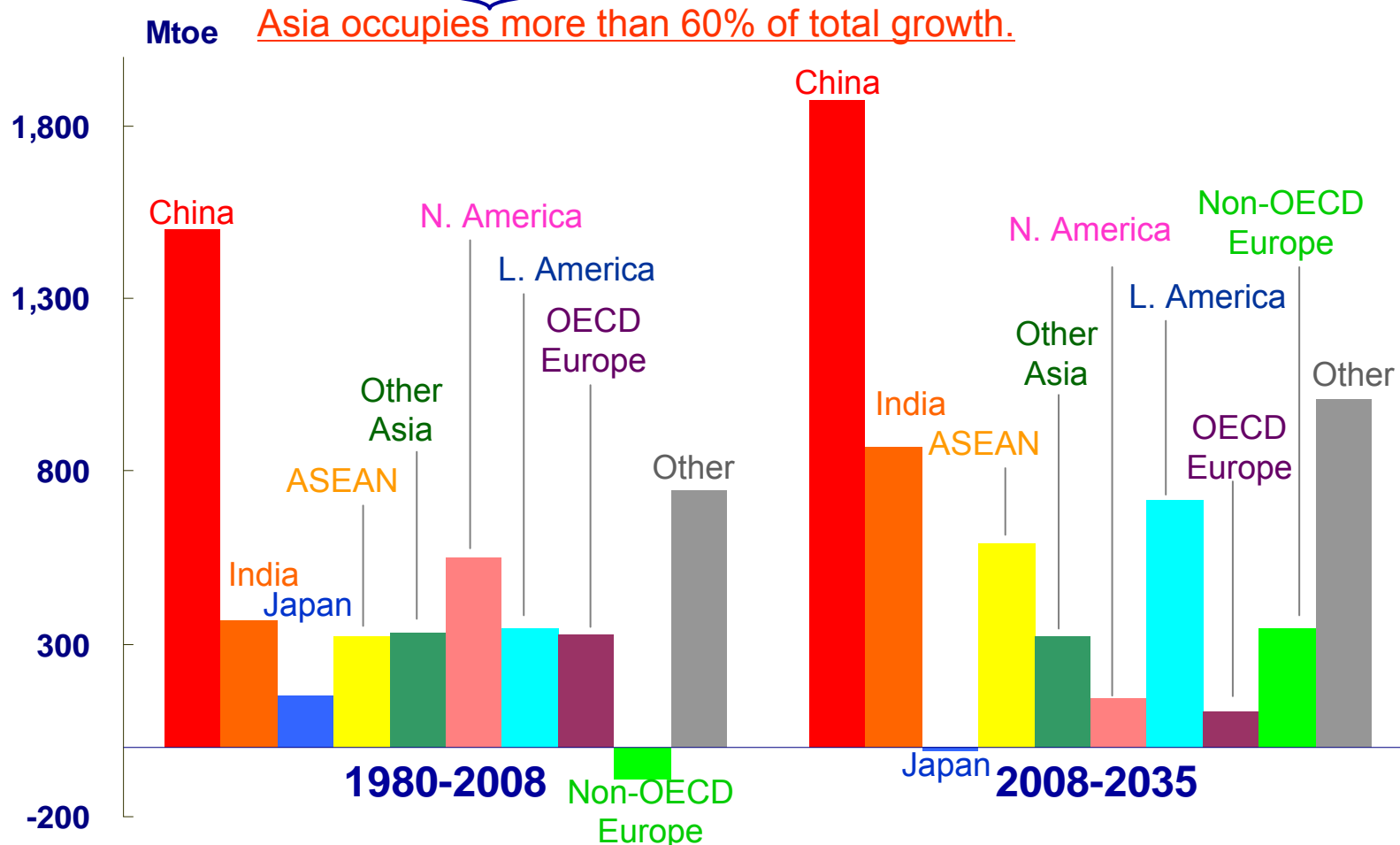
※ASEAN7: Indonesia, Malaysia, Thailand, Philippines, Vietnam, Singapore, and Brunei



Increase in Primary Energy Demand by Region Reference

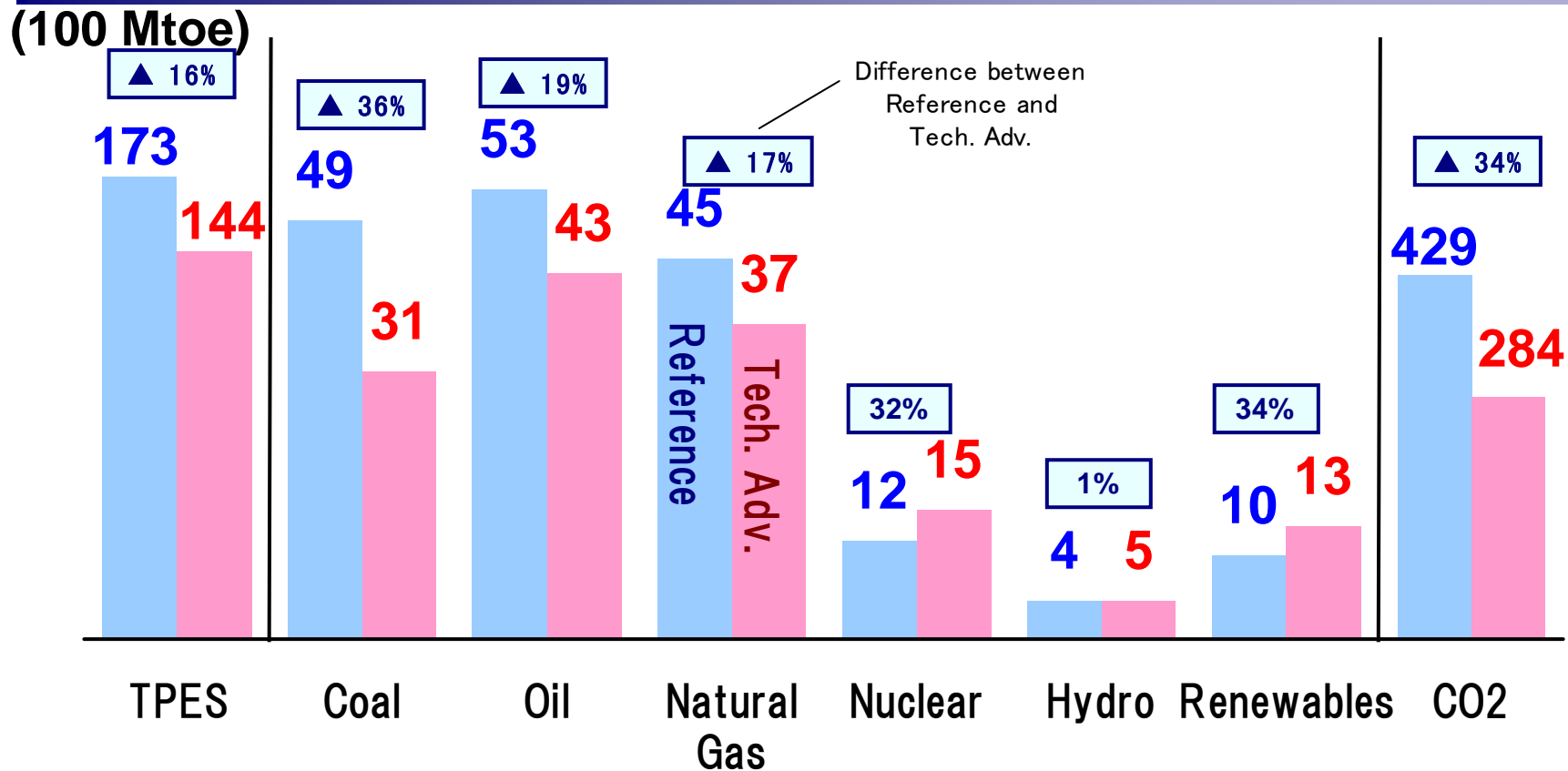
Share in increase (2008-2035)

China	India	Japan	ASEAN	Other Asia	N. America	OECD Europe
31%	15%	0%	10%	5%	2%	2%



■ Asia will account for 62% of the world energy demand growth through 2035. In particular, China and India will account for approximately 50% the world energy demand growth. OECD is responsible for 8%, and Non-OECD 92%.

Comparisons: Reference and Tech. Adv. Scenarios in 2035 (World)

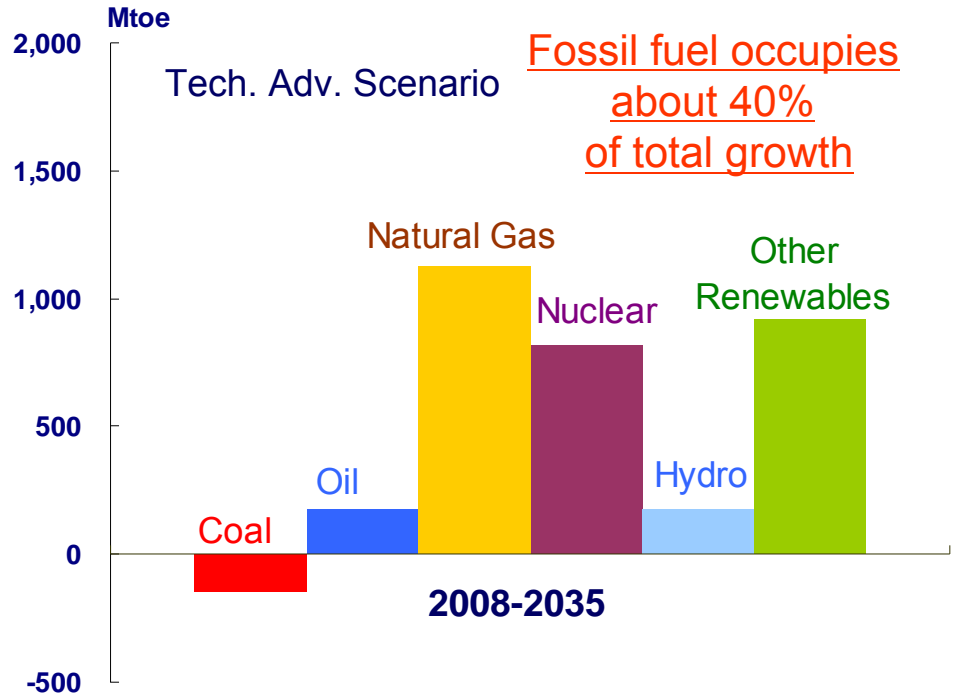
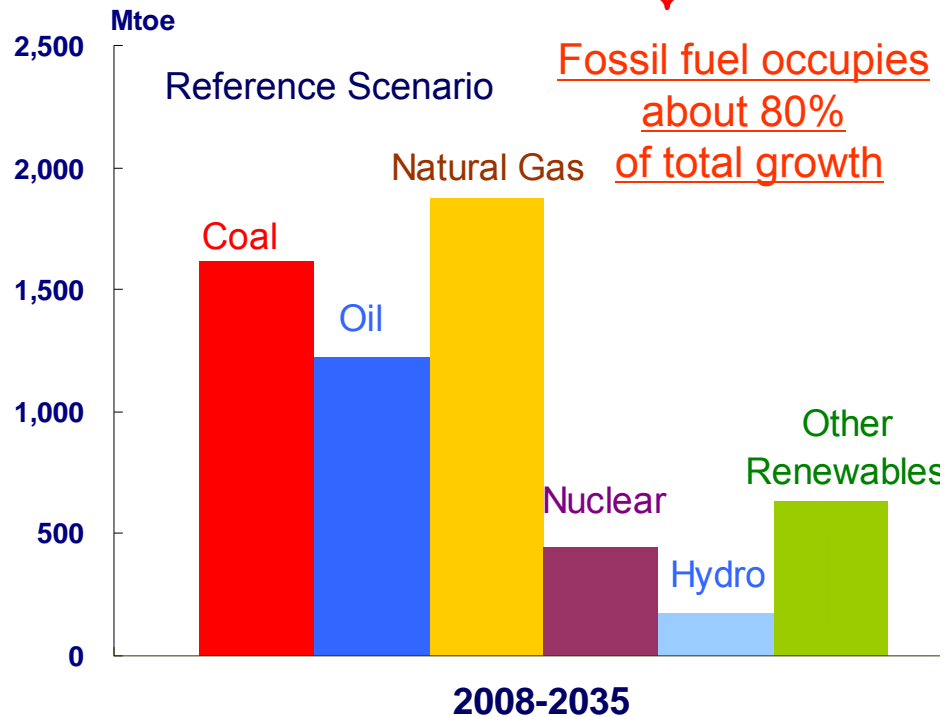


- In 2035, the world fossil fuel demand will reach 14.7 bil. toe in the Reference Scenario, while it will account for 11.1 bil. toe in the Tech. Adv. Scenario. Global non-fossil fuel demand in 2035 will account for 2.6 bil. toe in the Reference Scenario, while it will reach 3.3 bil. toe in the Tech. Adv. Scenario.
- Coal demand shows notable difference between the Reference and the Tech. Adv. scenario, due to assumed deployment of clean coal technologies in the Tech. Adv. Scenario.
- The world oil demand in 2035 will be 107 mb/d in the Reference Scenario in contrast to 87 mb/d in the Tech. Adv. Scenario reflecting assumed improvement in vehicles fuel efficiency. Similarly, by 2035 oil demand in Asia will reach 38.6 mb/d in the Reference Scenario, compared with that of 30.1 mb/d in the Tech. Adv. Scenario.

Increase in Primary Energy Demand by Fuel (World)

Increase in 2008-2035

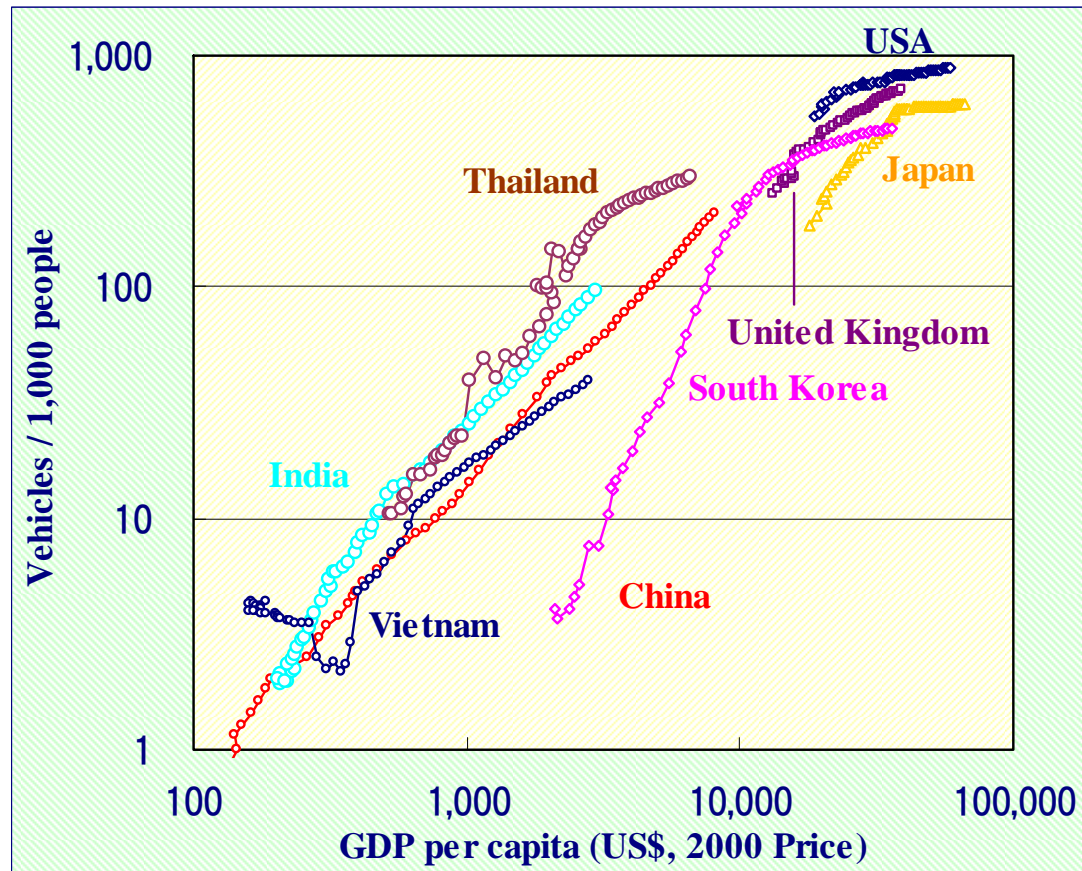
	Coal	Oil	Natural Gas	Nuclear	Hydro	Other Renewables
Reference	27 %	21 %	31 %	7 %	3 %	11 %
Tech. Adv.	-5%	6%	37%	27%	6%	30%



- In the Reference Scenario, 79% of global energy growth by 2035 will be fossil fuels, and in the Tech. Adv. Scenario, it will be 38%.
- In the Reference Scenario, Non-OECD will be responsible for about 90% of global fossil demand growth.

Vehicle Stocks per 1,000 Population (Selected Countries)

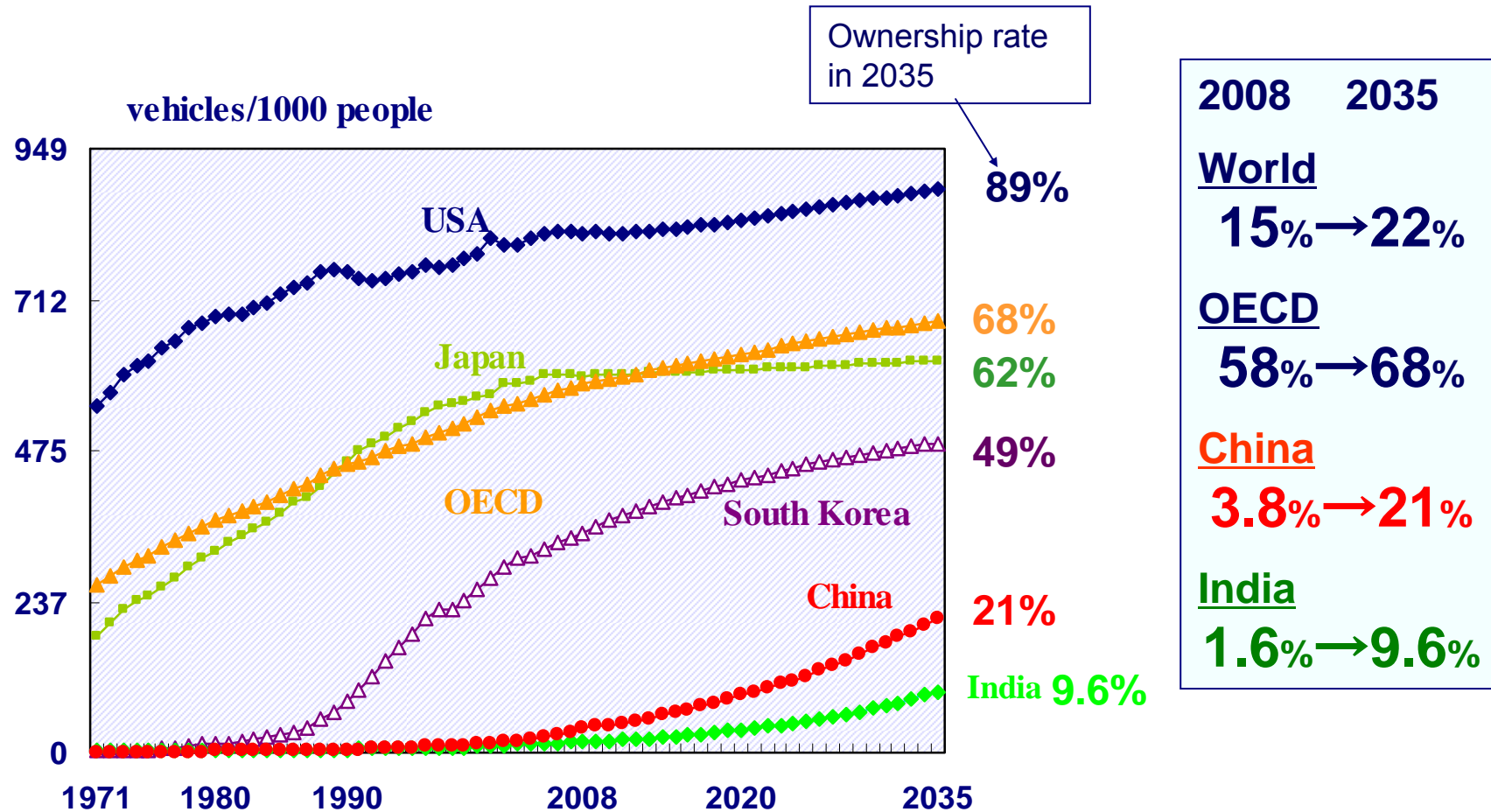
* Including actual data and forecast results, 1971-2035



The vehicle ownership will increase steadily with growing income.



Vehicle Ownership Rate



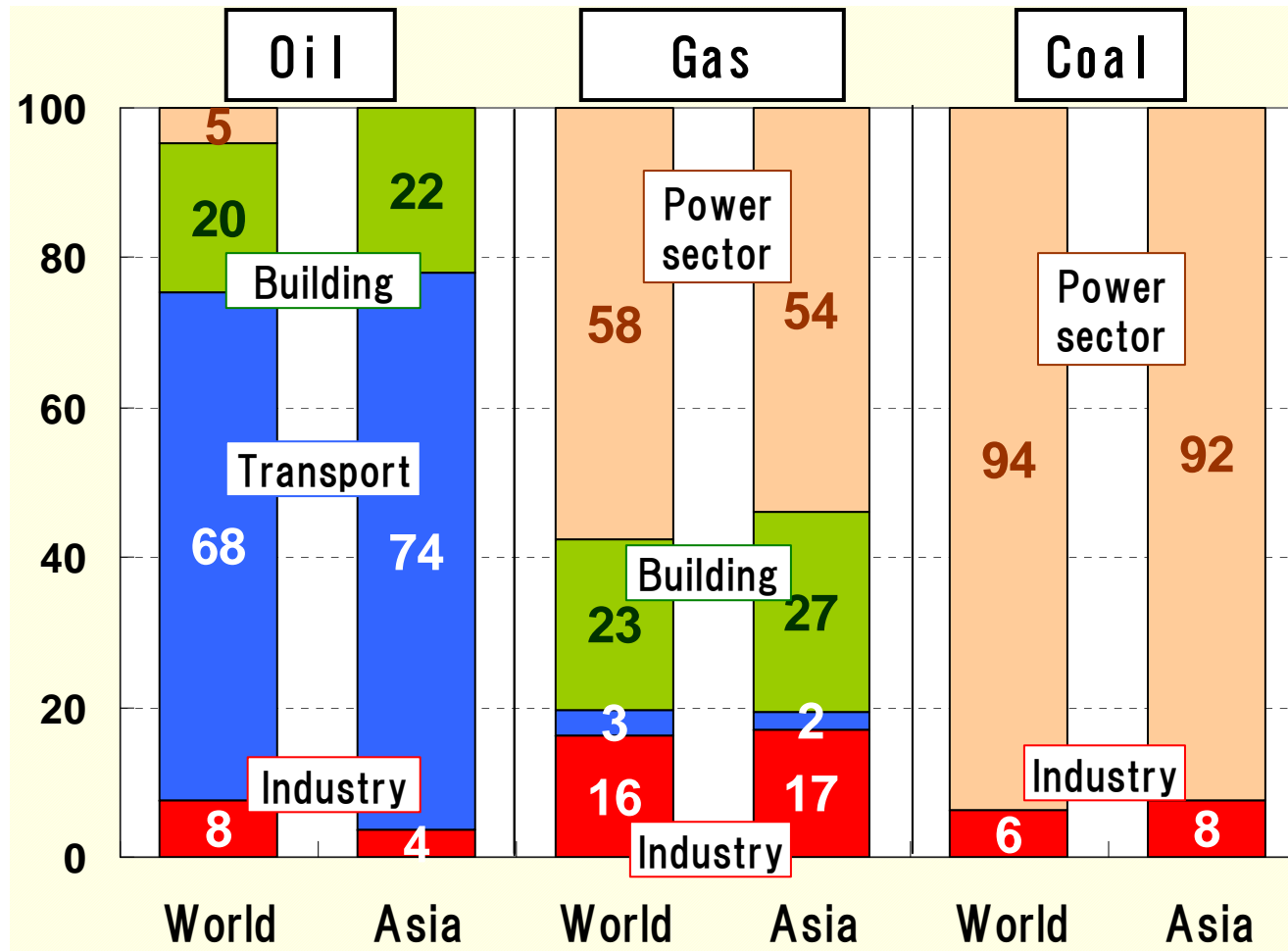
- Vehicle ownership rate will make progress mainly in Asian nations, the majority of which achieve high economic growth during 2008-2035.
- Although the number of vehicles is projected to expand robustly in China and India, the vehicle ownership rates will still remain well below that of developed countries. As a result, these countries have a large potential to grow still after 2035.

Incremental Growth in Primary Energy by Type of Fuel (2008-2035, World and Asia)



Reference

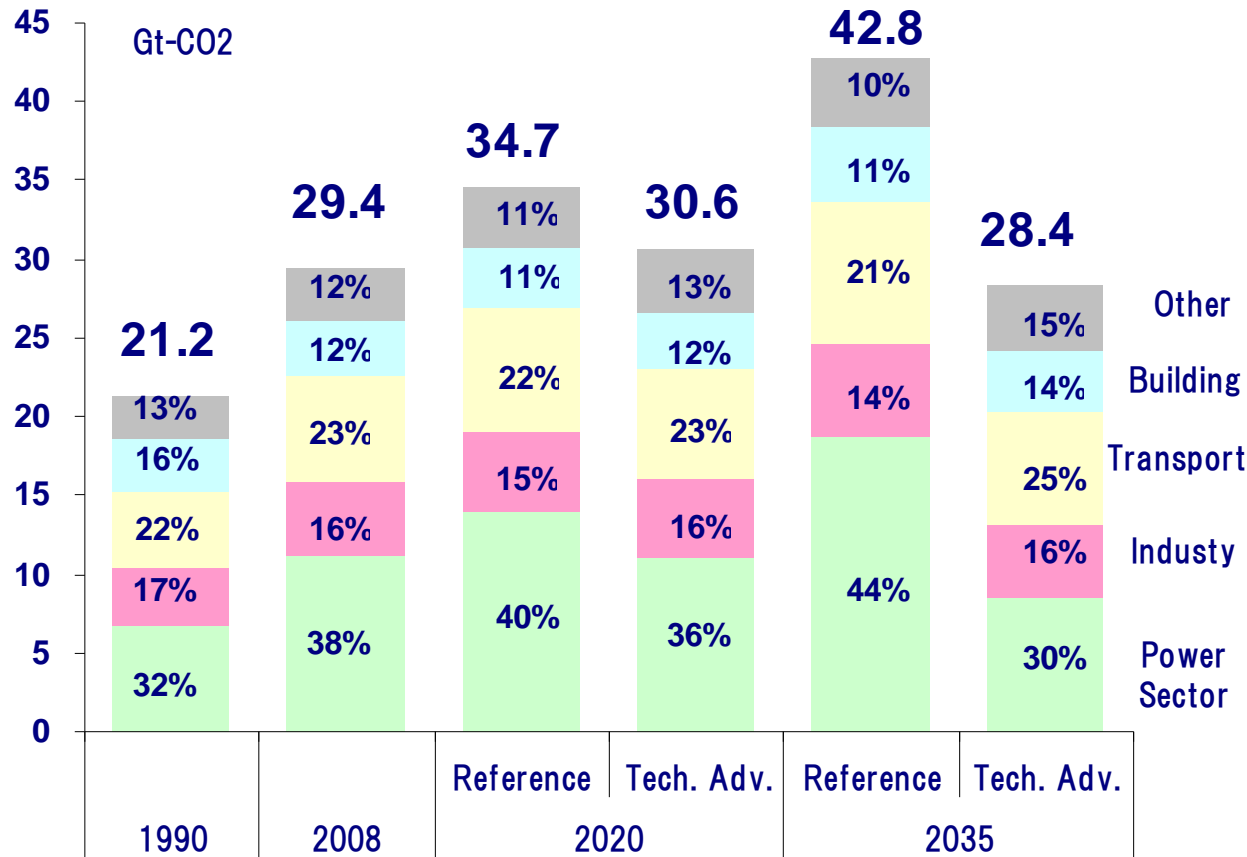
【Contributions by Sector, %】



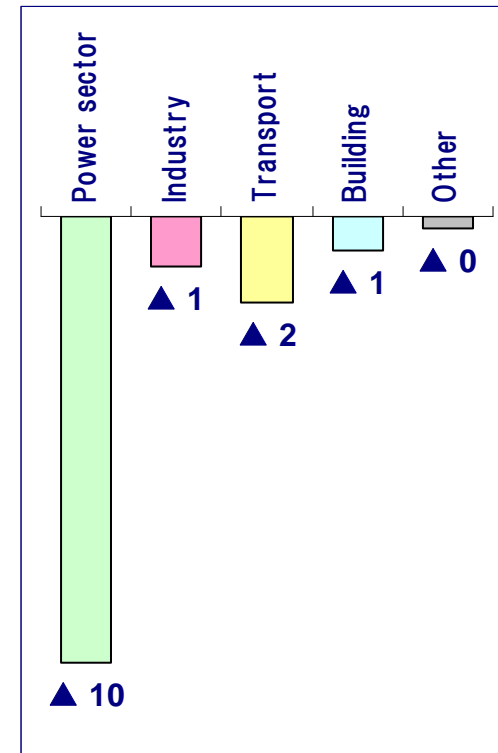
In both Asia and the world, oil will mainly increase in the transport sector, while natural gas and coal will increase in the power sector.

CO₂ Emissions by Sector (World)

Reference
Tech. Adv.



Difference between
Reference and Tech.
Adv. (2035)



- In the Tech. Adv. Scenario, CO₂ emissions in the power sector will be 10 Gt-CO₂ lower and that in final energy demand will be 4.3 Gt-CO₂ lower compared to Reference Scenario.
- Improving power generation efficiency and energy saving of electricity will be the most important options for CO₂ emissions reduction.

CO₂ Decomposition Analysis

Unit: AAGR

		Asia (ex.Japan)			China (2008-2035)		India (2008-2035)	
		1980- 2008	2008-2035		Referece	Tech.Adv.	Referece	Tech.Adv.
			Referece	Tech.Adv.				
CO ₂	ΔC	5.3	2.4	0.5	1.9	▲ 0.2	3.8	1.5
	Decarbonization $\Delta(C/E)$	2.4	▲ 1.6	▲ 1.0	▲ 0.7	▲ 1.7	▲ 0.2	▲ 0.4
	Energy conservation $\Delta(E/Y)$	▲ 3.9	▲ 1.0	▲ 3.5	▲ 3.0	▲ 4.0	▲ 2.4	▲ 4.3
	Economic grow th ΔY	7.0	5.1		5.7		6.5	

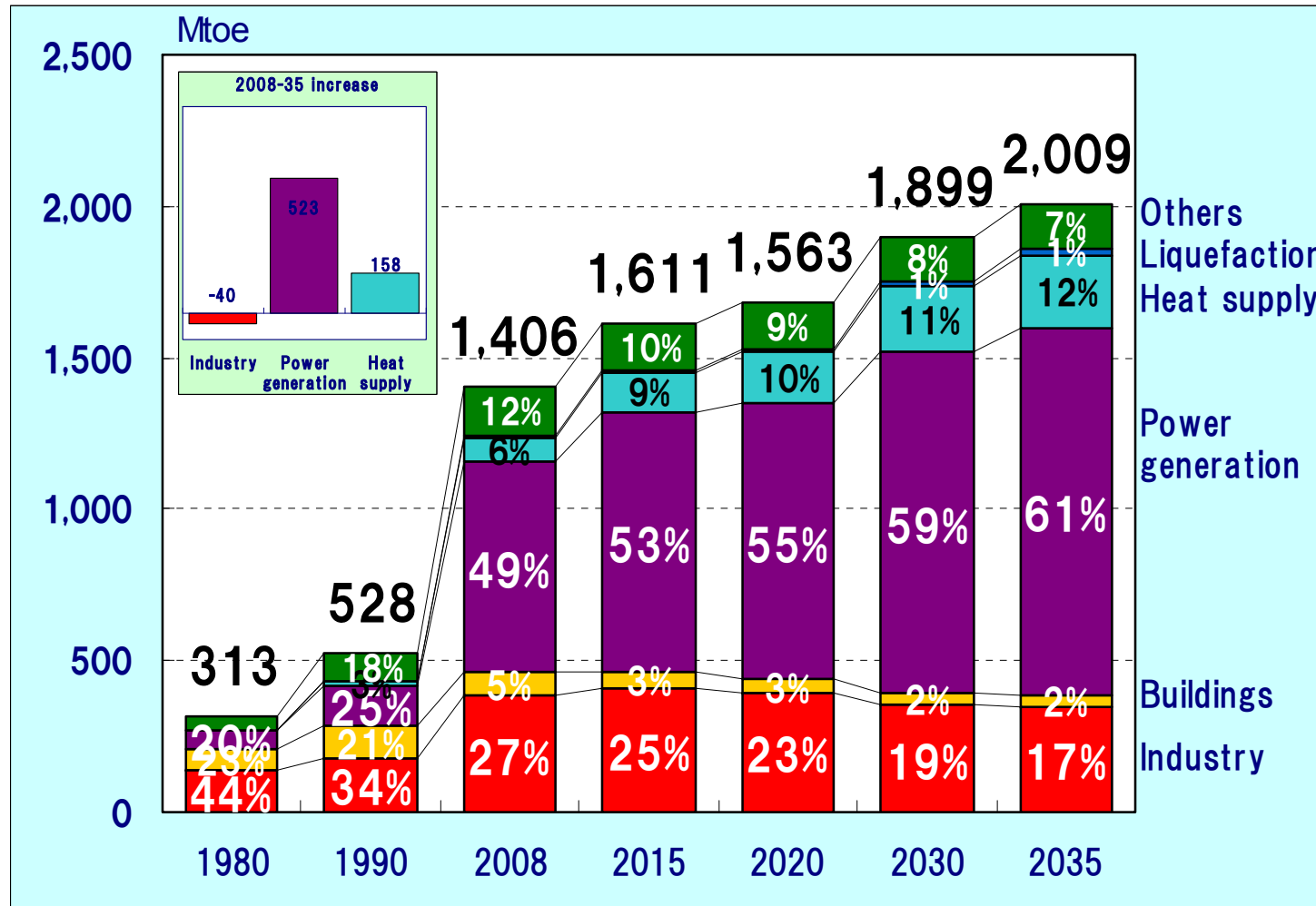
The change of CO₂ is divided into 3 factors

$$C = (C/E) * (E/Y) * Y$$

$$\Delta C = \Delta(C/E) + \Delta(E/Y) + \Delta Y$$

Decarbonization Energy Saving Economic Growth

Coal Demand by Sector in China

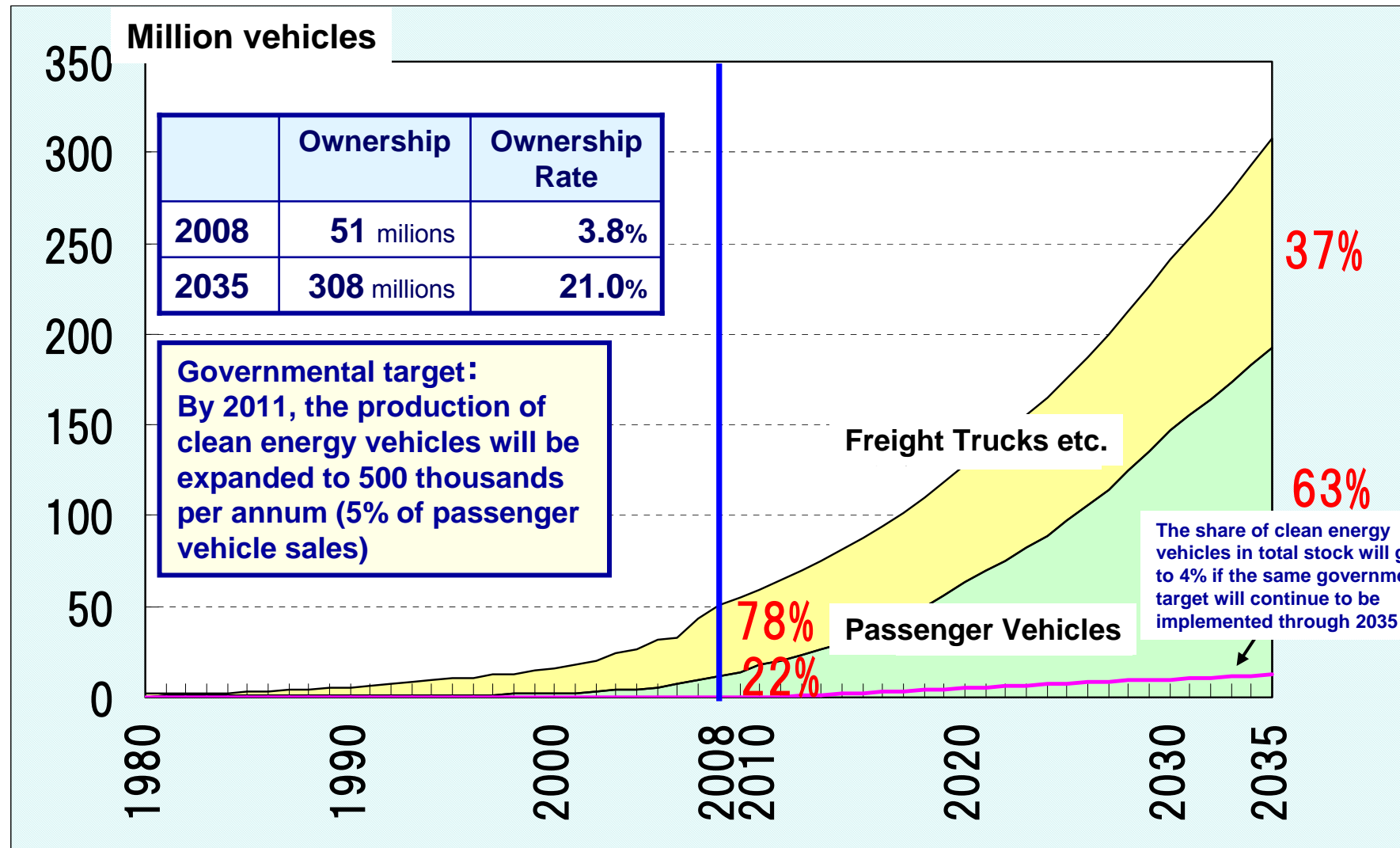


Coal Demand (Mtoe)

2008
1,410
 ↓
 2035
2,010
 (1.4times)

- Currently, the power sector accounts for 49% of the world coal demand, and this ratio is expected to increase to 61% by 2035.
- Coal demand in the industry sector will remain at the 2008 level through 2035 because of slowing down of steel production.

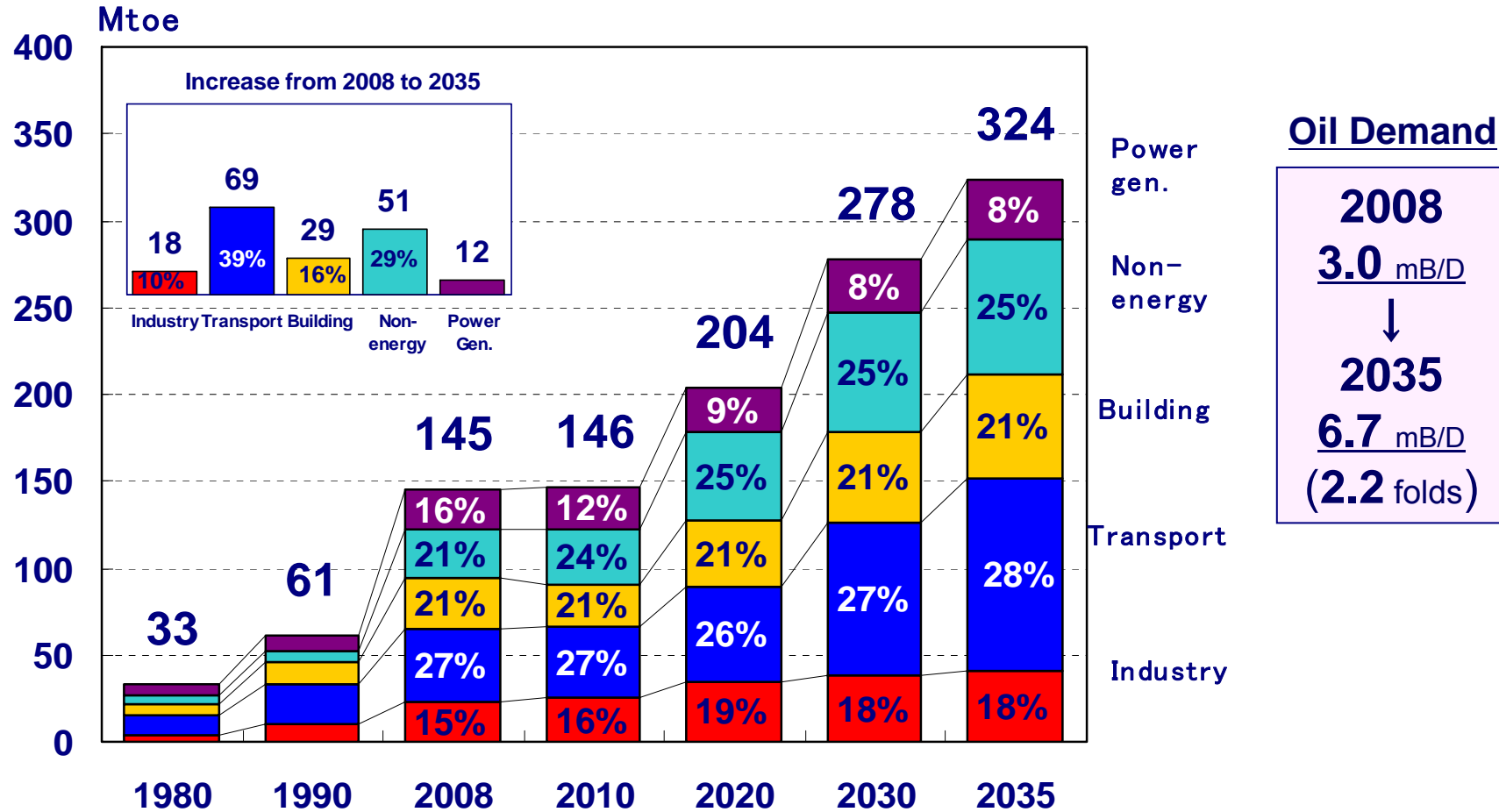
Vehicle Stocks in China



Vehicle stocks in China will increase to approximately 300 million units in 2035; 190 million units of which are passenger vehicle stocks.

Oil Demand in India

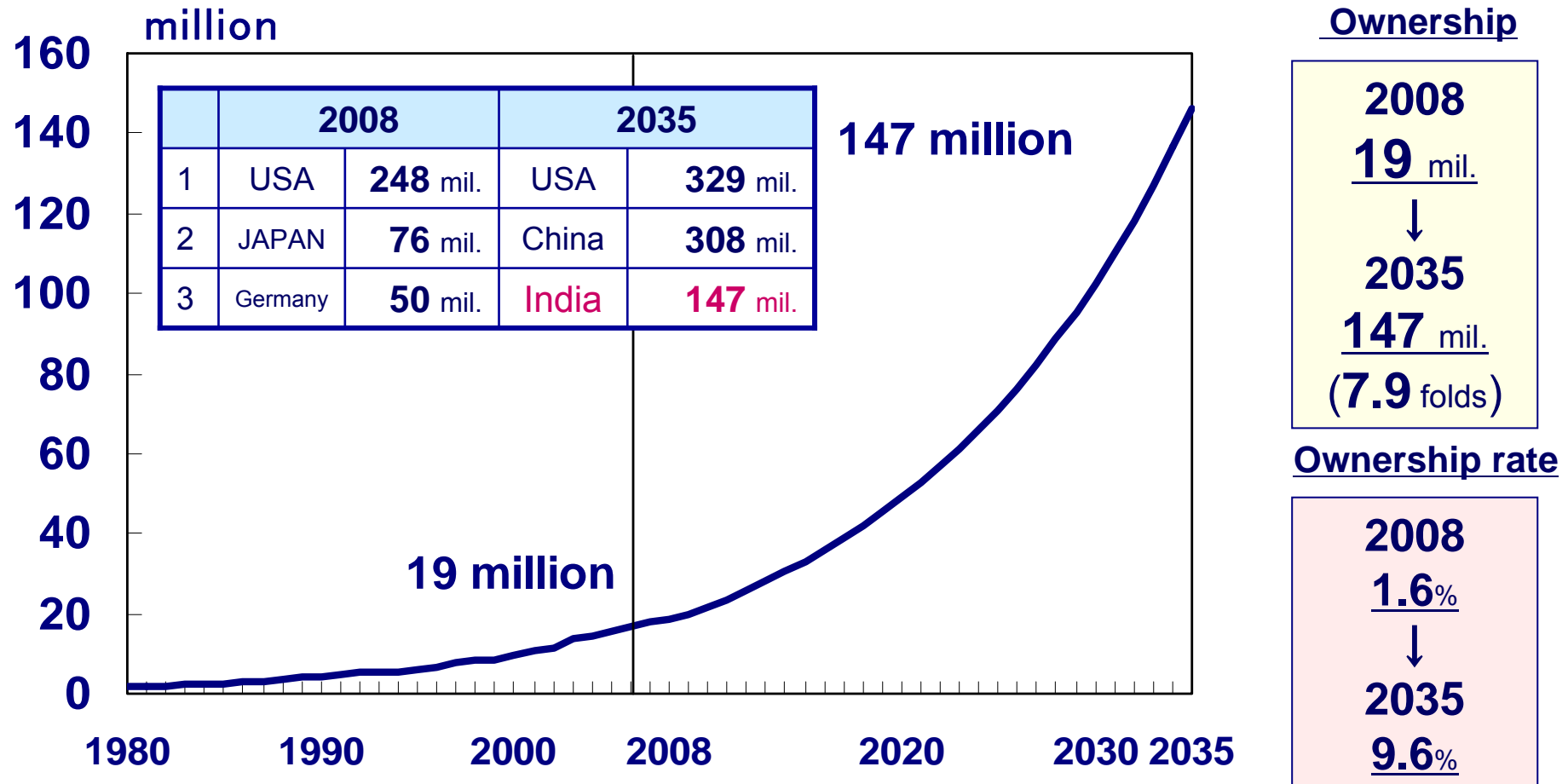
Reference Scenario



Oil demand will sharply increase in the transport sector due to motorization and in industry and residential/commercial sectors.

Between 2008 and 2035, India's incremental growth in oil demand will account for 3.7 mb/d, which is almost equal to current oil consumption in Japan. India will be the world's **140** third-largest oil consumer behind USA and China by 2035.

Vehicle Stocks in India



■ Demand for public transport such as railways and buses is relatively-large at the present. However due to the income growth and improvement of road network, India's vehicle stocks will increase substantially. As a result, India will be the world's third-largest vehicle owner behind USA and China in 2035.

■ Ownership ratio will be still 9.6% in 2035. There is a great potential for further increase.