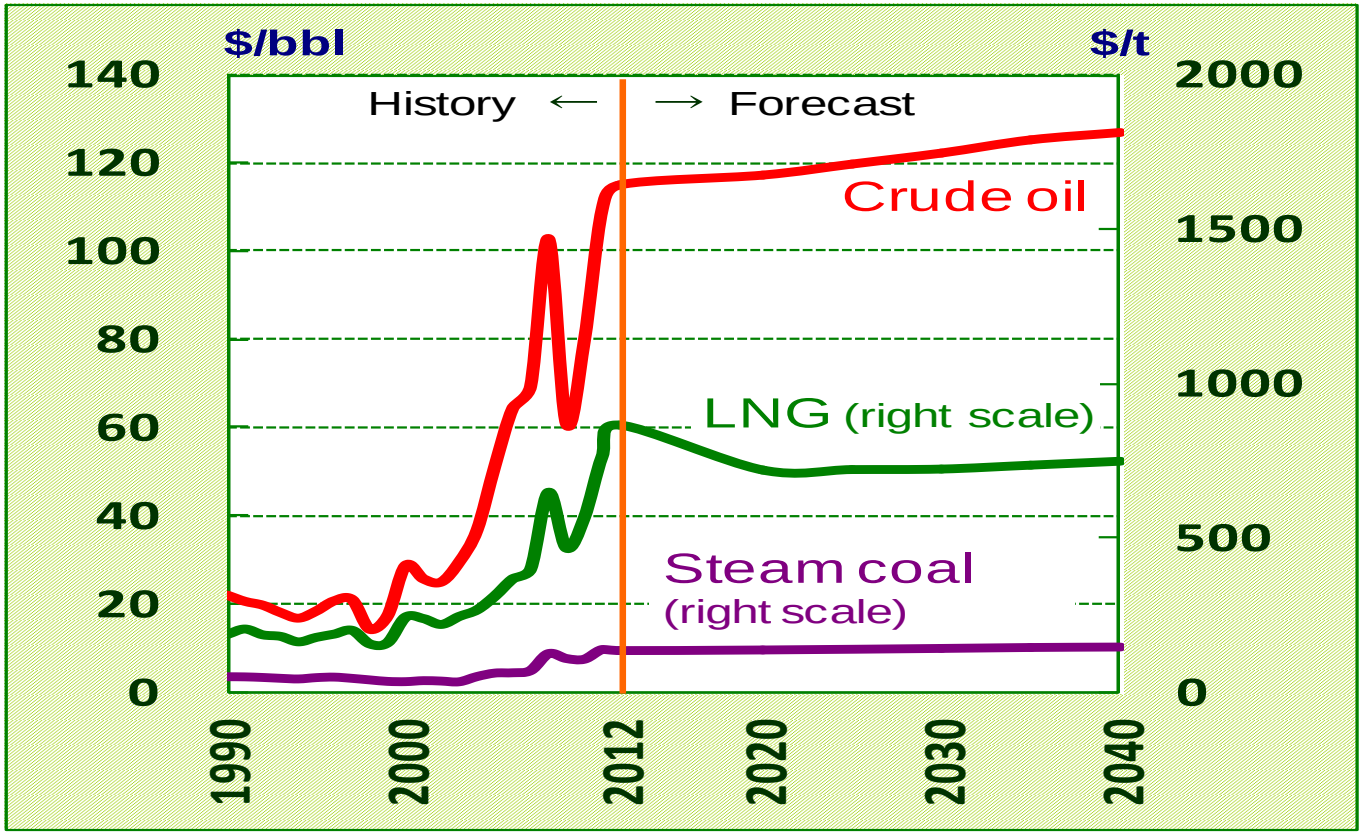
CNPC-IEEJ WS
12 Dec. 2013, Beijing, China

Asia/ World Energy Outlook 2013

The Institute of Energy Economics, Japan (IEEJ)

Yukari Yamashita

Outlook Assumptions: Primary Energy Prices



(Note 1) Prices are for calendar years. Forecast prices are in 2012 dollars.
(Note 2) Japan's energy prices are on a CIF import basis.

Source: IEEJ (Asia/World Energy Outlook 2013)

Scenarios

Reference Scenario

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

Advanced Technology Scenario

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

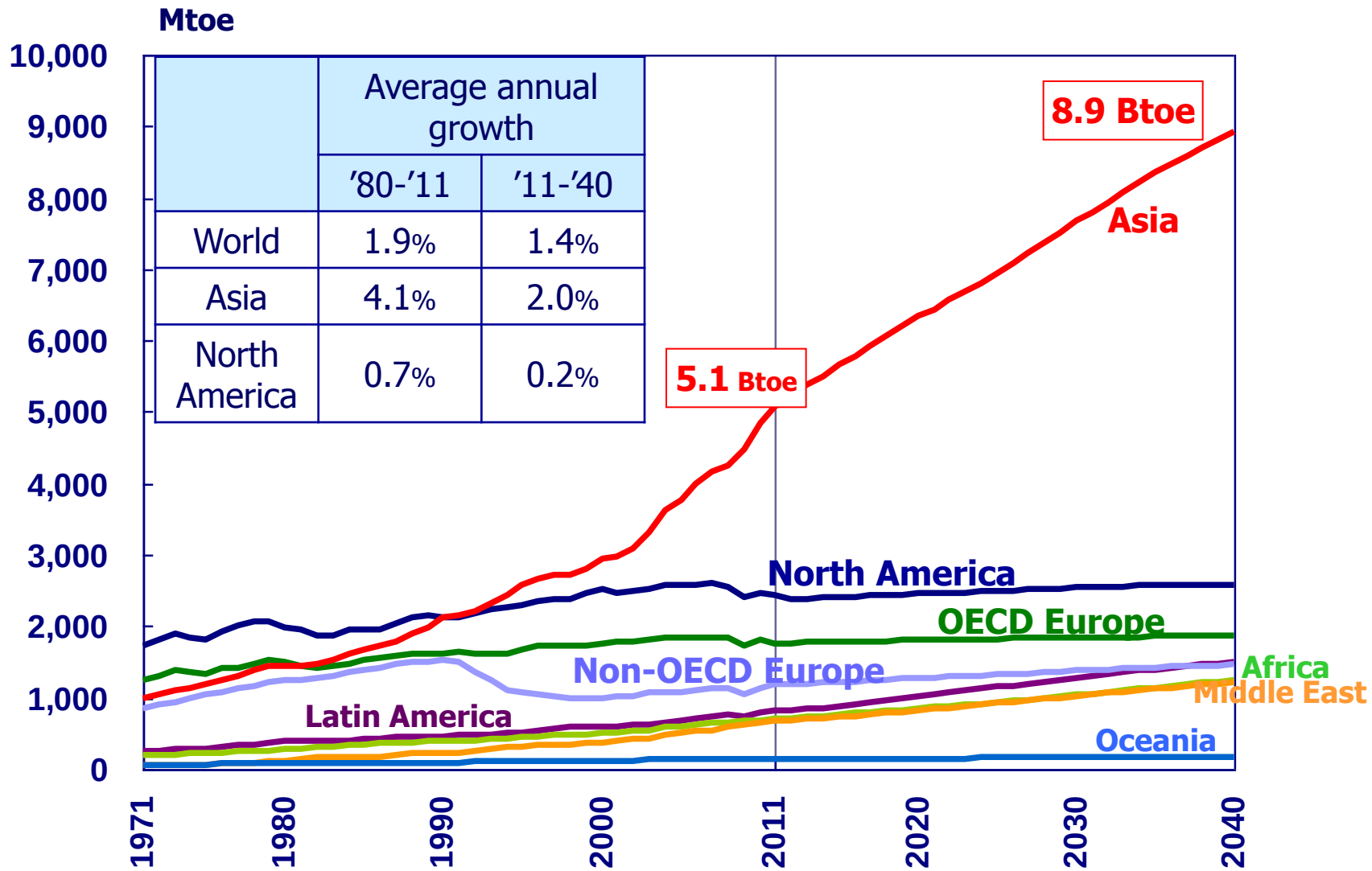
Enhanced Unconventional Resources Development Scenario

Using the Reference Scenario as a starting point, this scenario maximizes the development of unconventional fossil fuel resources, including shale oil and gas. This scenario identifies the global impacts of such development on energy supply and demand.

Source: IEEJ (Asia/World Energy Outlook 2013)

Primary Energy Demand by Region

Reference Scenario

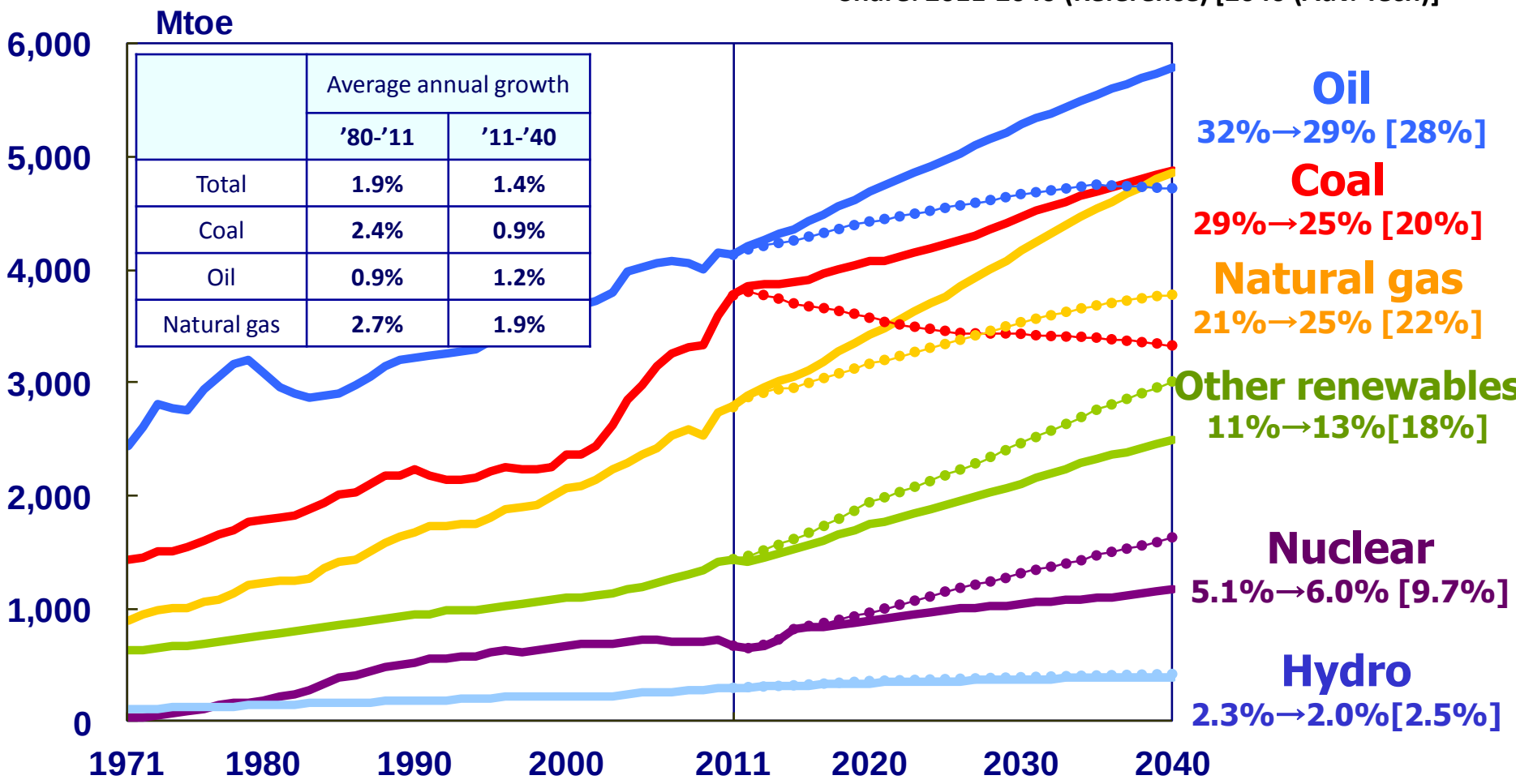


Source: IEEJ (Asia/World Energy Outlook 2013)

Global Primary Energy Consumption

Solid line ------Ref. Scenario
Dotted line··Adv. Tech.

Share: 2011-2040 (Reference) [2040 (Adv. Tech)]



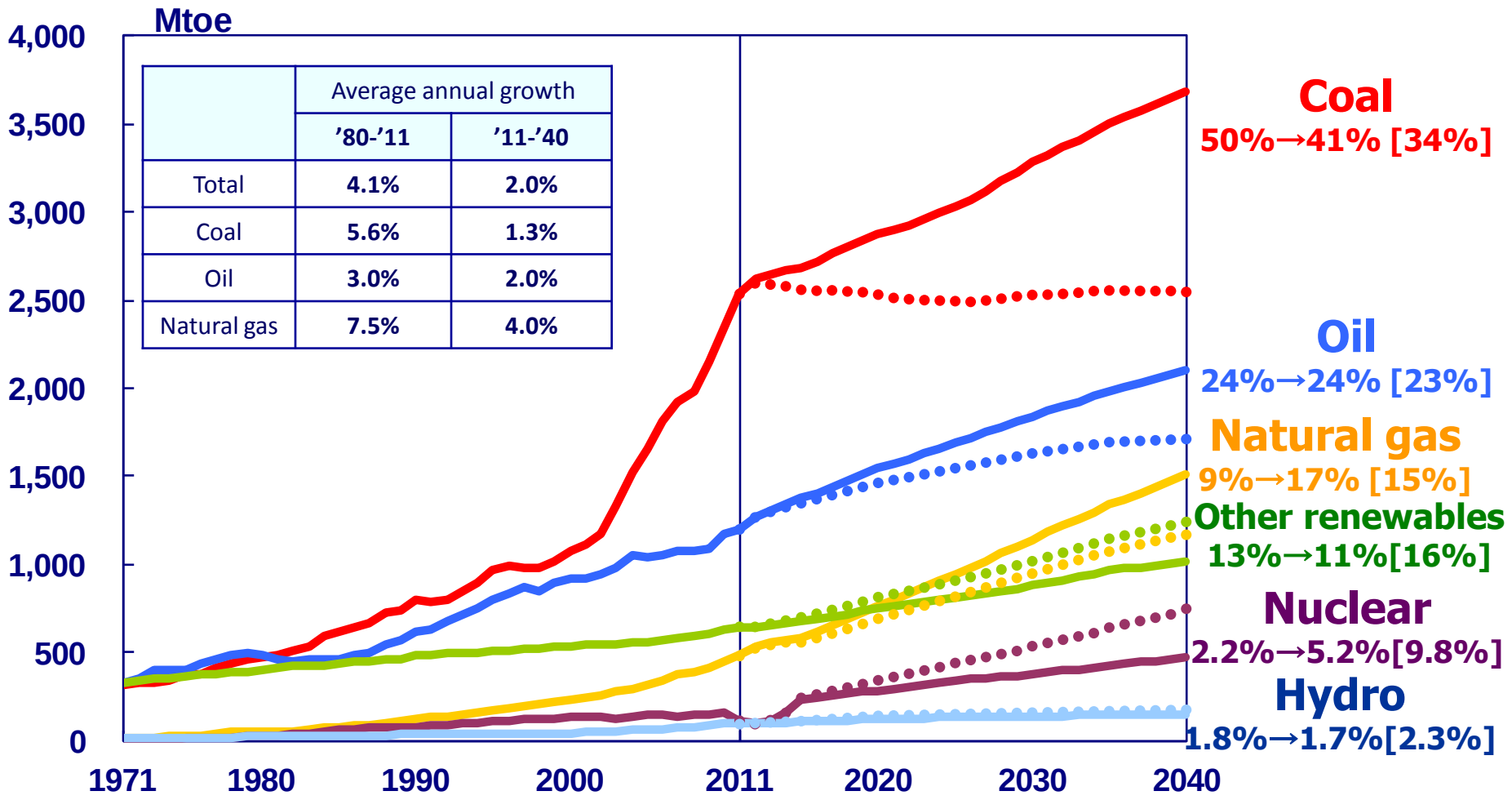
	Average annual growth	
	’80-’11	’11-’40
Total	1.9%	1.4%
Coal	2.4%	0.9%
Oil	0.9%	1.2%
Natural gas	2.7%	1.9%

Source: IEEJ (Asia/World Energy Outlook 2013)

Asian Primary Energy Consumption

Solid line ------Ref. Scenario
Dotted line··Adv. Tech.

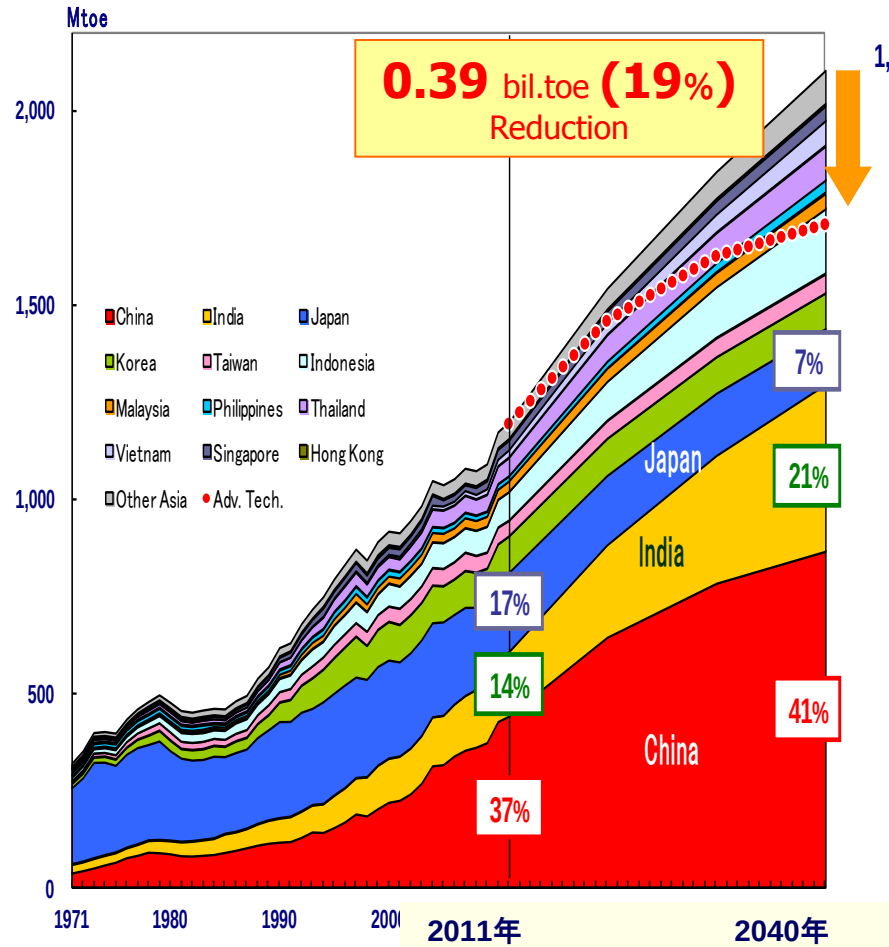
Share: 2011-2040 (Reference) [2040 (Adv. Tech)]



	Average annual growth	
	’80-’11	’11-’40
Total	4.1%	2.0%
Coal	5.6%	1.3%
Oil	3.0%	2.0%
Natural gas	7.5%	4.0%

Source: IEEJ (Asia/World Energy Outlook 2013)

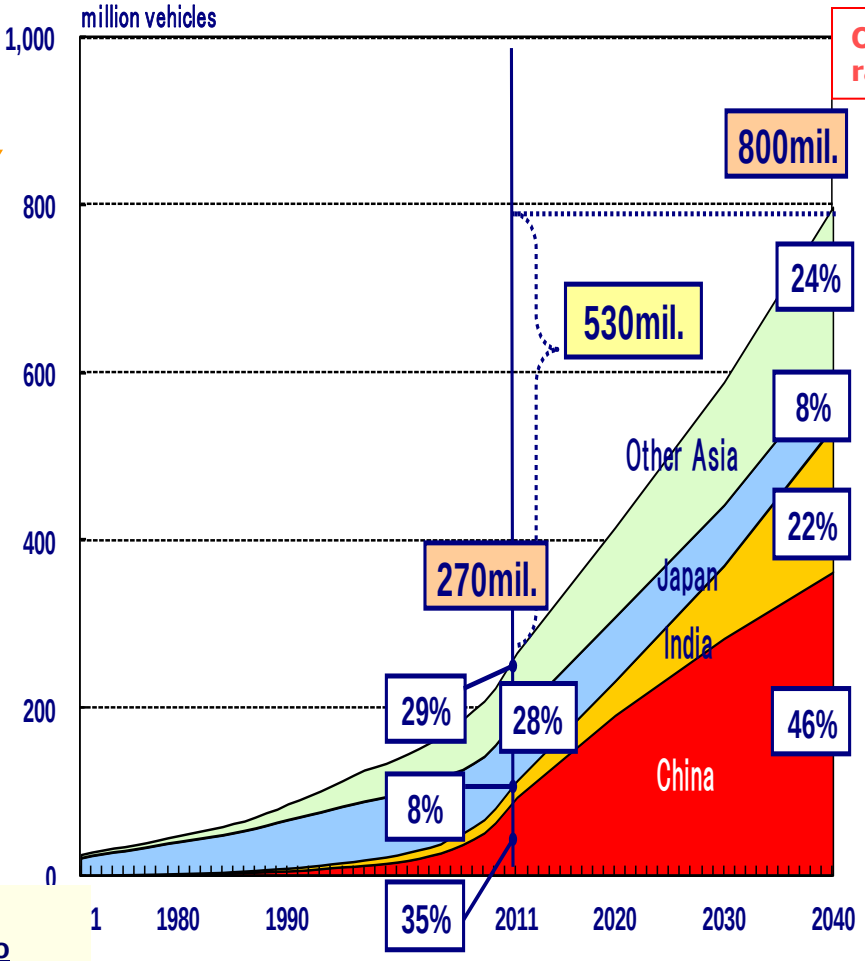
Oil Demand by Region (Asia)



2011年
1.2 Btoe
(24.5MB/D)

2040年
Ref. Scenario
2.1Btoe
(43.0M B/D)
Adv. Tech.
1.7Btoe
(35.1M B/D)

Car Ownership(Asia)

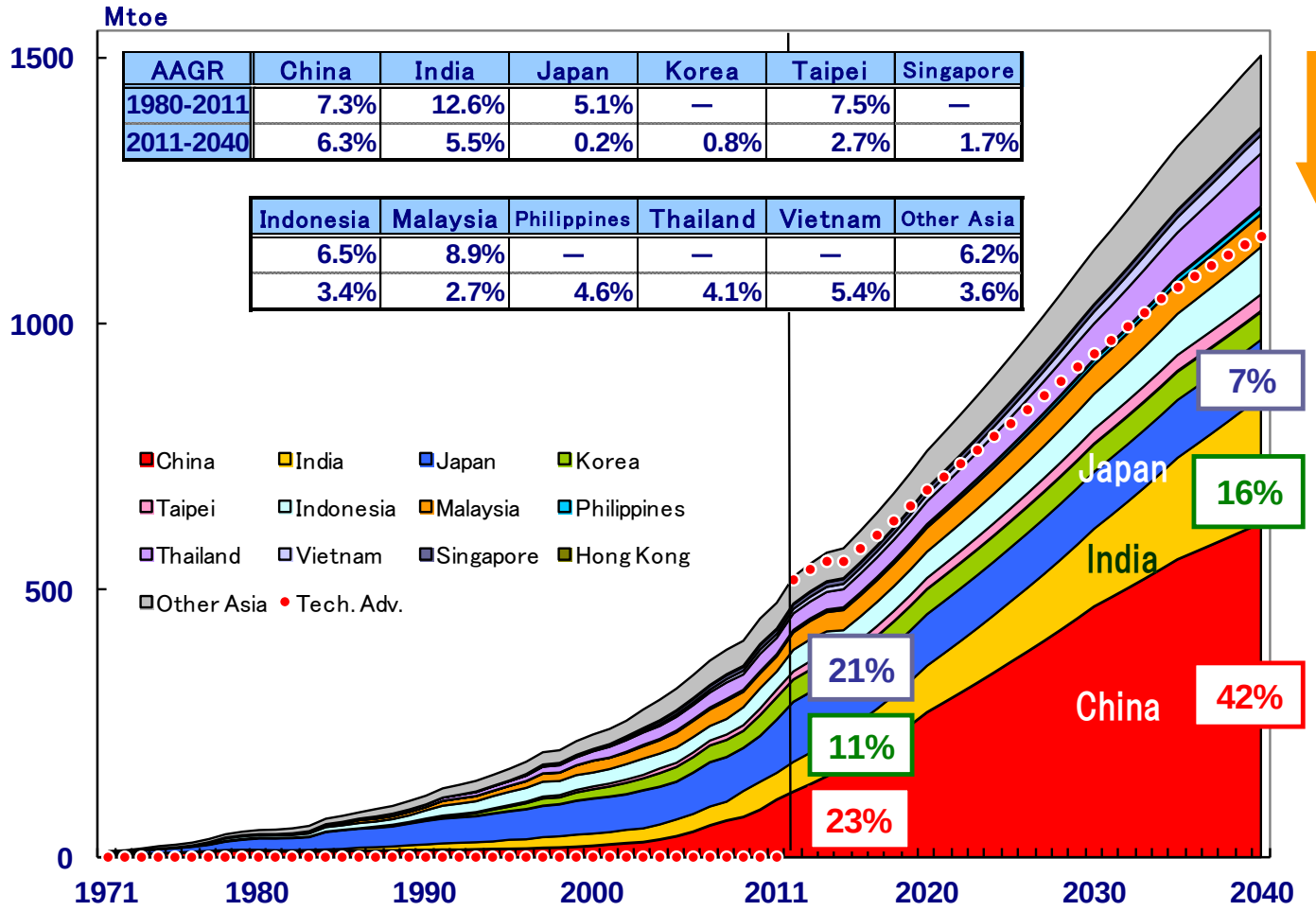


Source: IEEJ (Asia/World Energy Outlook 2013)

Natural Gas Demand by Country (Asia)

AAGR	China	India	Japan	Korea	Taipei	Singapore
1980-2011	7.3%	12.6%	5.1%	—	7.5%	—
2011-2040	6.3%	5.5%	0.2%	0.8%	2.7%	1.7%

Indonesia	Malaysia	Philippines	Thailand	Vietnam	Other Asia
6.5%	8.9%	—	—	—	6.2%
3.4%	2.7%	4.6%	4.1%	5.4%	3.6%



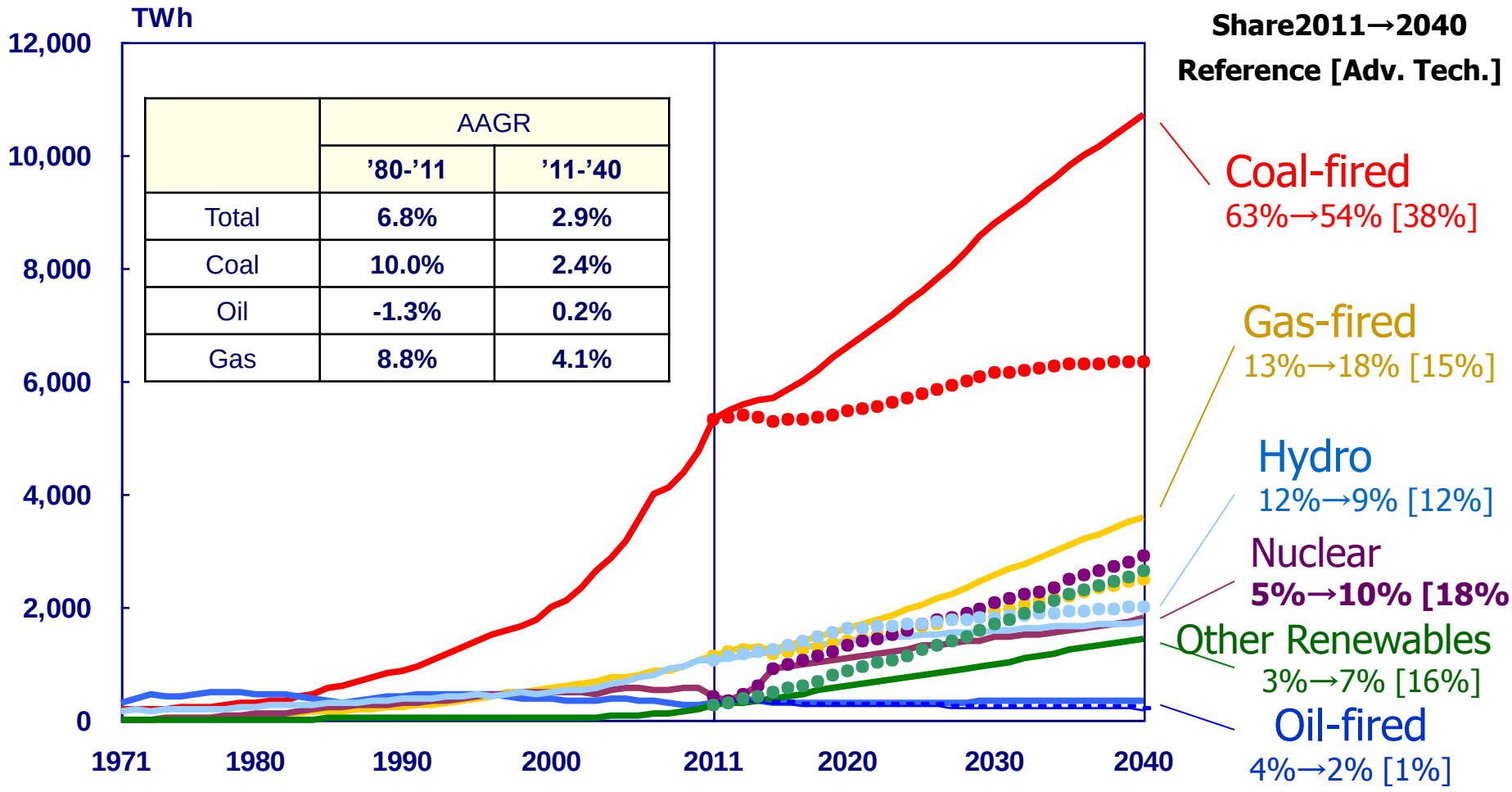
Reference
Adv. Tech.

340 Mtoe (23%) Reduction

Source: IEEJ (Asia/World Energy Outlook 2013)

Power Generation Mix by Source (Asia)

Solid line: Reference
Dotted line: Adv. Tech.

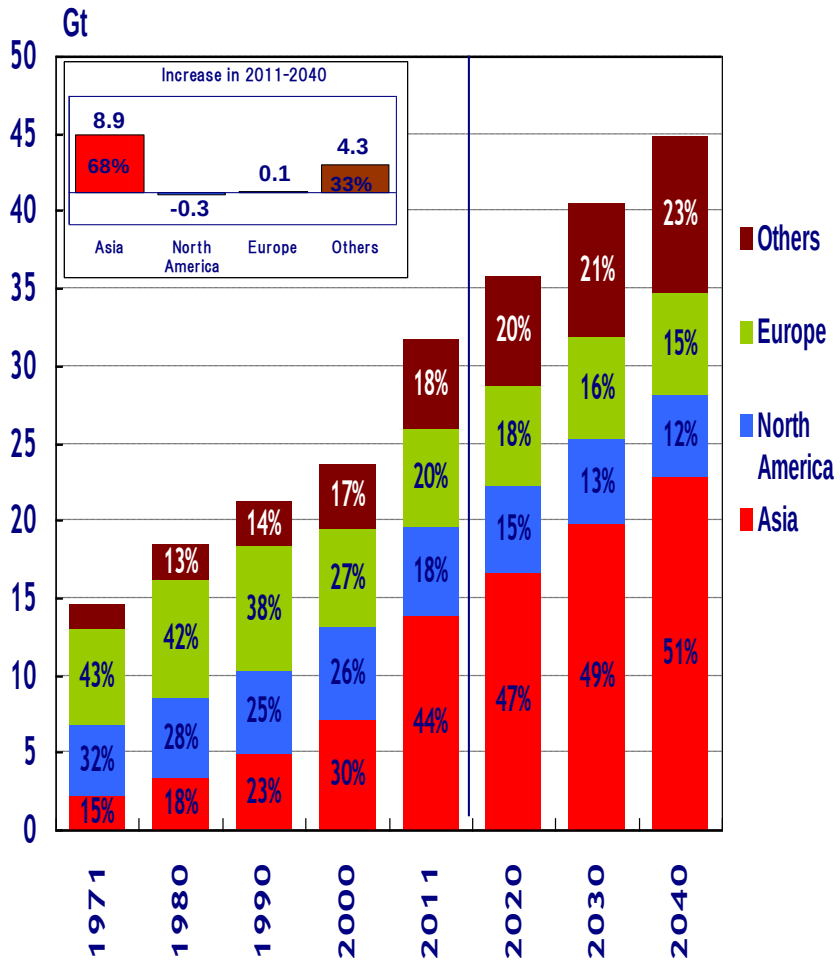


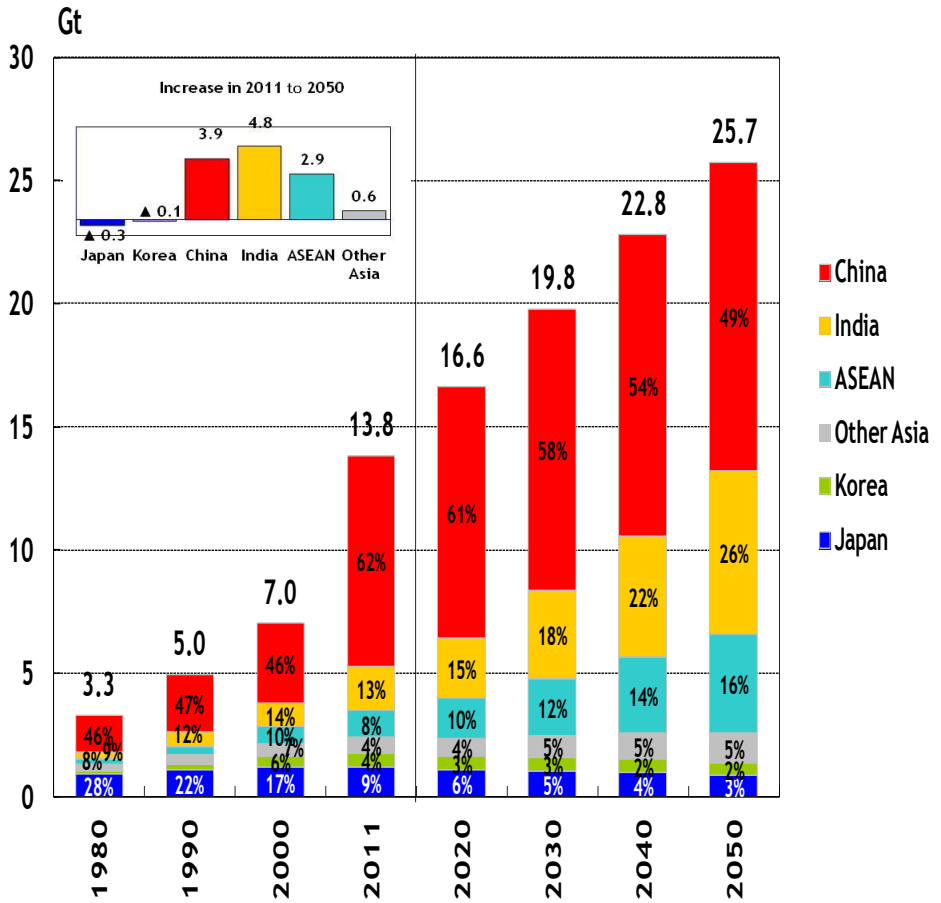
	AAGR	
	’80-’11	’11-’40
Total	6.8%	2.9%
Coal	10.0%	2.4%
Oil	-1.3%	0.2%
Gas	8.8%	4.1%

Source: IEEJ (Asia/World Energy Outlook 2013)

CO_2 Emission by Region (World, Asia)

Reference

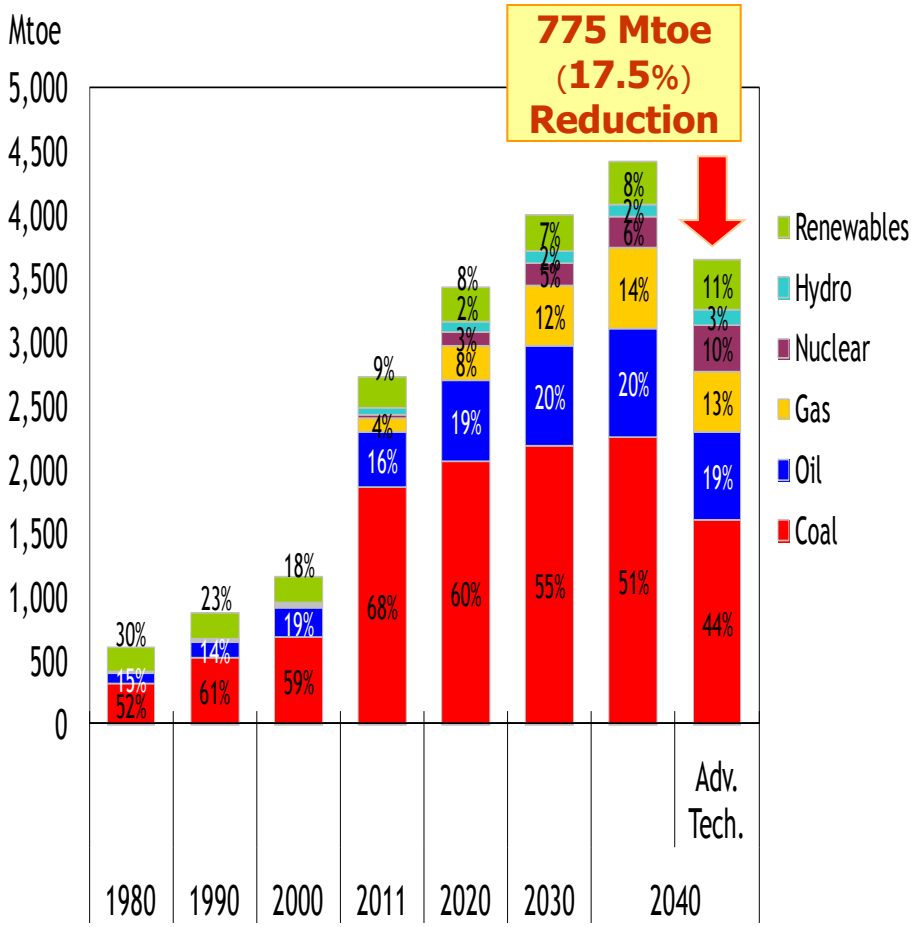


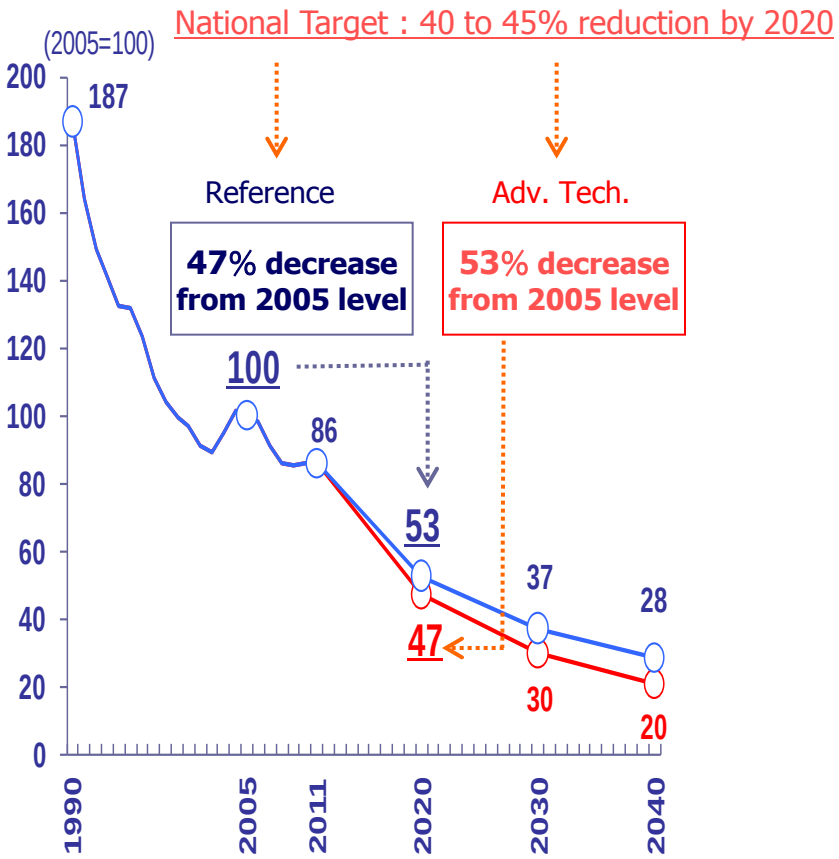


Source: IEEJ (Asia/World Energy Outlook 2013)

Primary Energy Demand in China

Reference
Adv. Tech.

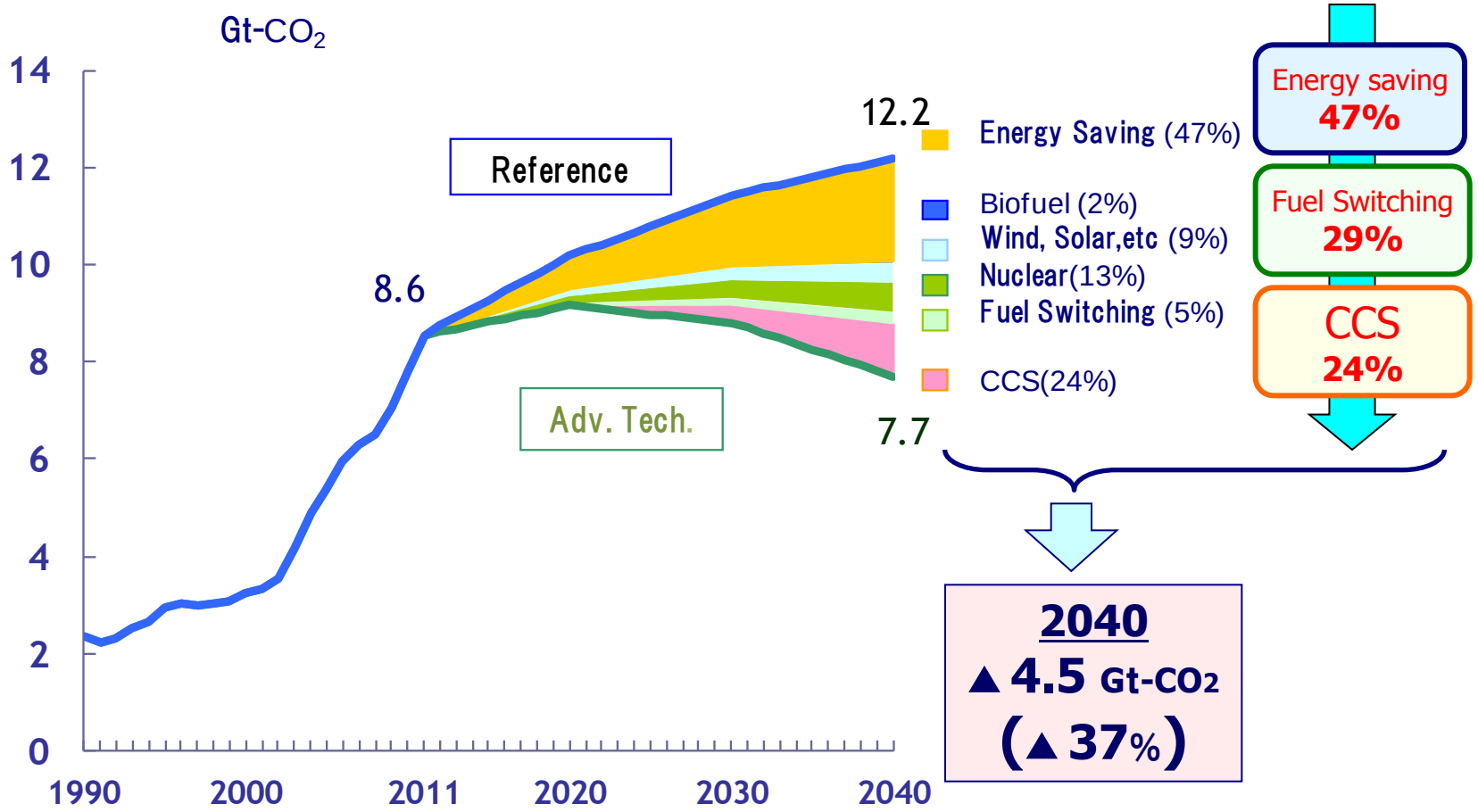




Source: IEEJ (Asia/World Energy Outlook 2013)

CO_2 Emissions in China

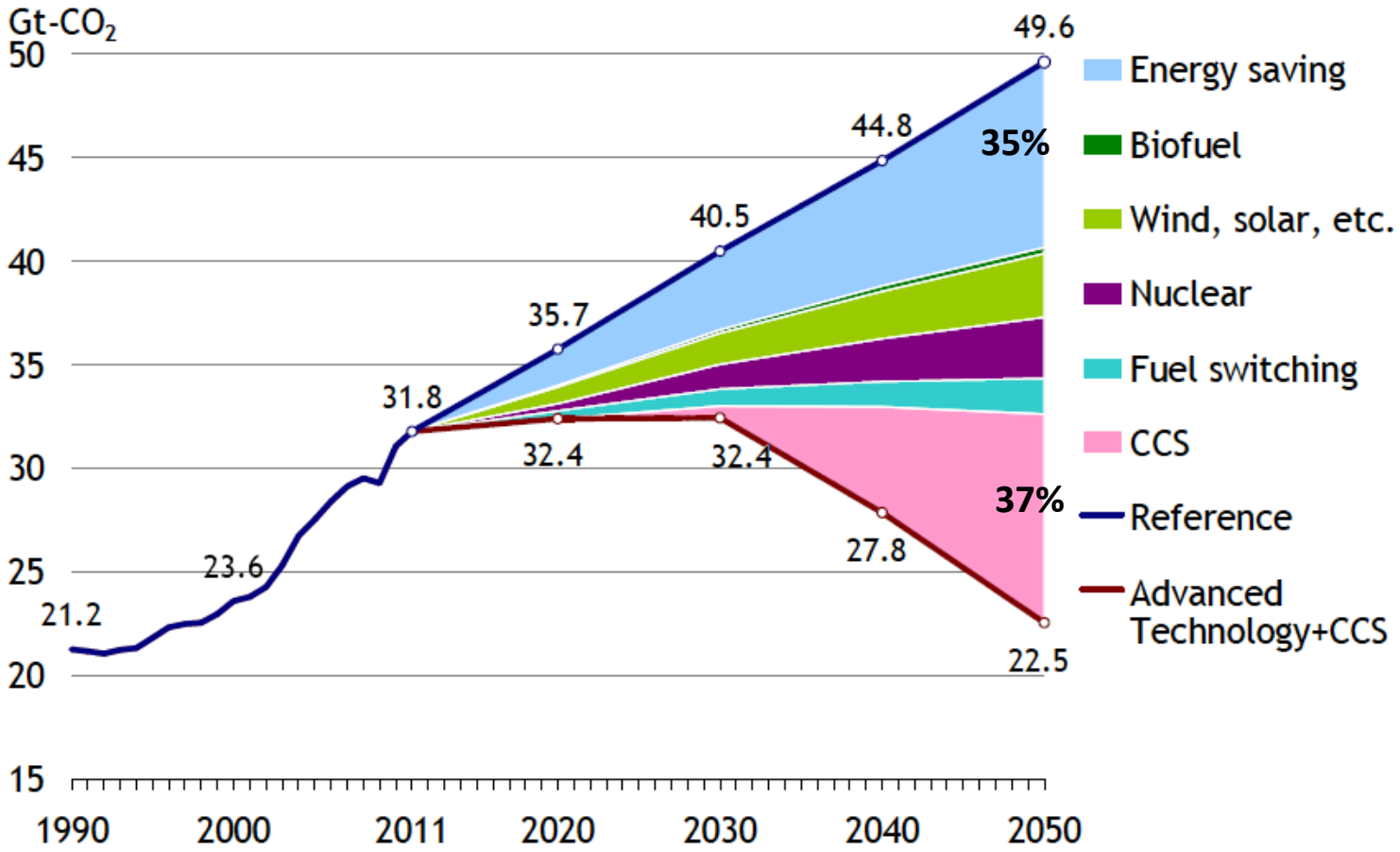
Reference
Adv. Tech.



Source: IEEJ (Asia/World Energy Outlook 2013)

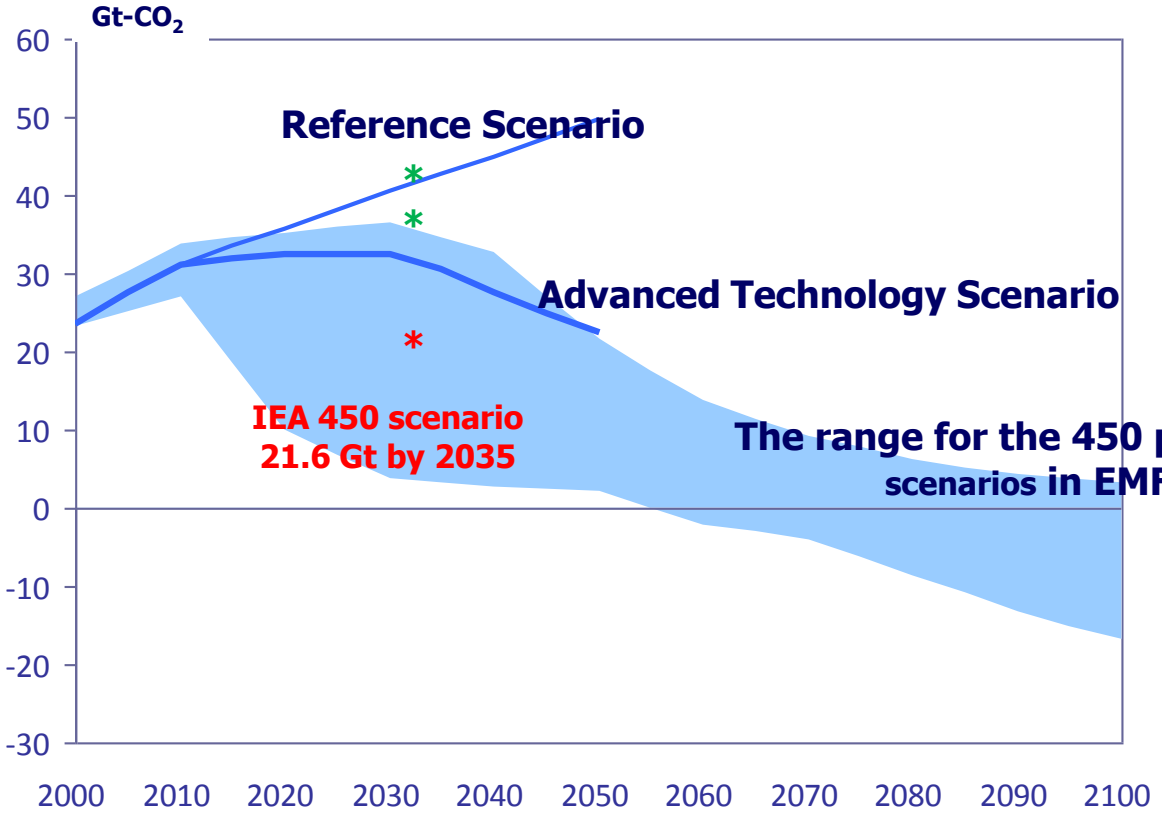
CO_2 World Emissions (by Reduction Measure)

Ref. Scenario
Adv. Tech. & CCS Scenario



Source: IEEJ (Asia/World Energy Outlook 2013)

CO_2 Emission Pathways for the Overshoot Scenario



(Source)

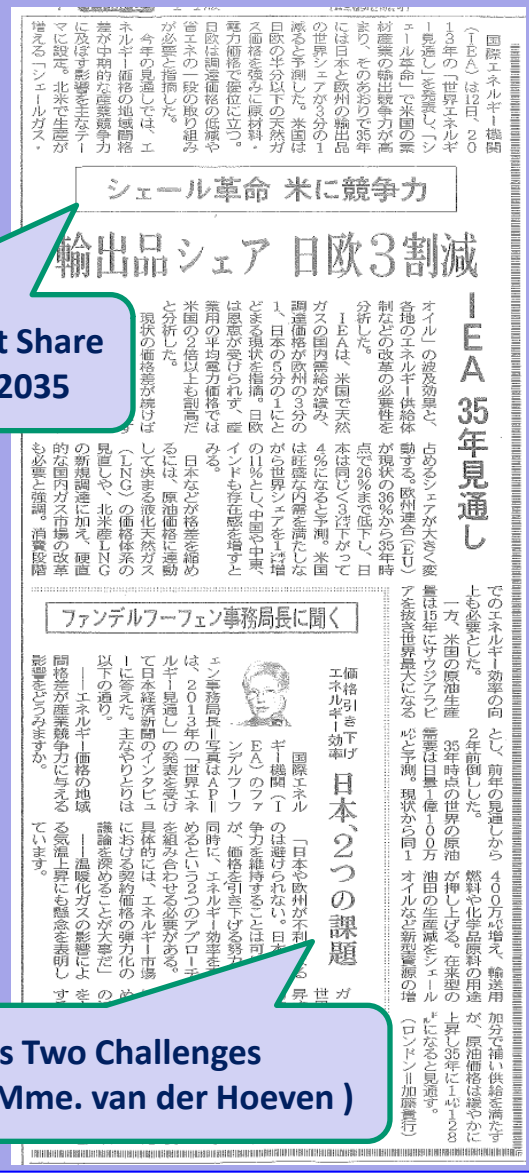
Clarke et al. (2009), "International climate policy architectures: Overview of the EMF 22 International Scenarios", *Energy Economics*, vol. 31, pp. 64-81.

- At the 22nd Working Group of the EMF (Energy Modeling Forum), the world's 10 major integrated assessment models participated in considering long-term GHG concentration and the presence or absence of an overshoot.

Source: IEEJ (Asia/World Energy Outlook 2013)

II.
Analyzing Changes Induced by the Shale Revolution

Nikkei (13 November 2013)



シェール革命 米に競争力

輸出品シェア 日欧3割減

IEA 35年見通し

ファンデルフーフェン事務局長に聞く

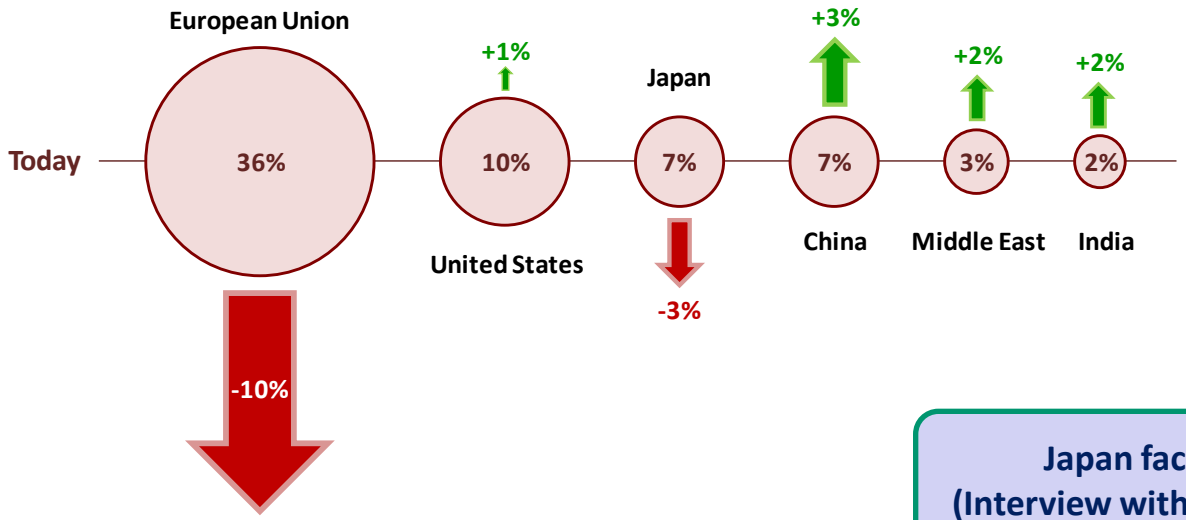
日本、2つの課題

価格引き下げ エネルギー効率

Japan and EU will lose Export Share by 30%: IEA's Outlook for 2035

Japan faces Two Challenges (Interview with Mme. van der Hoeven)

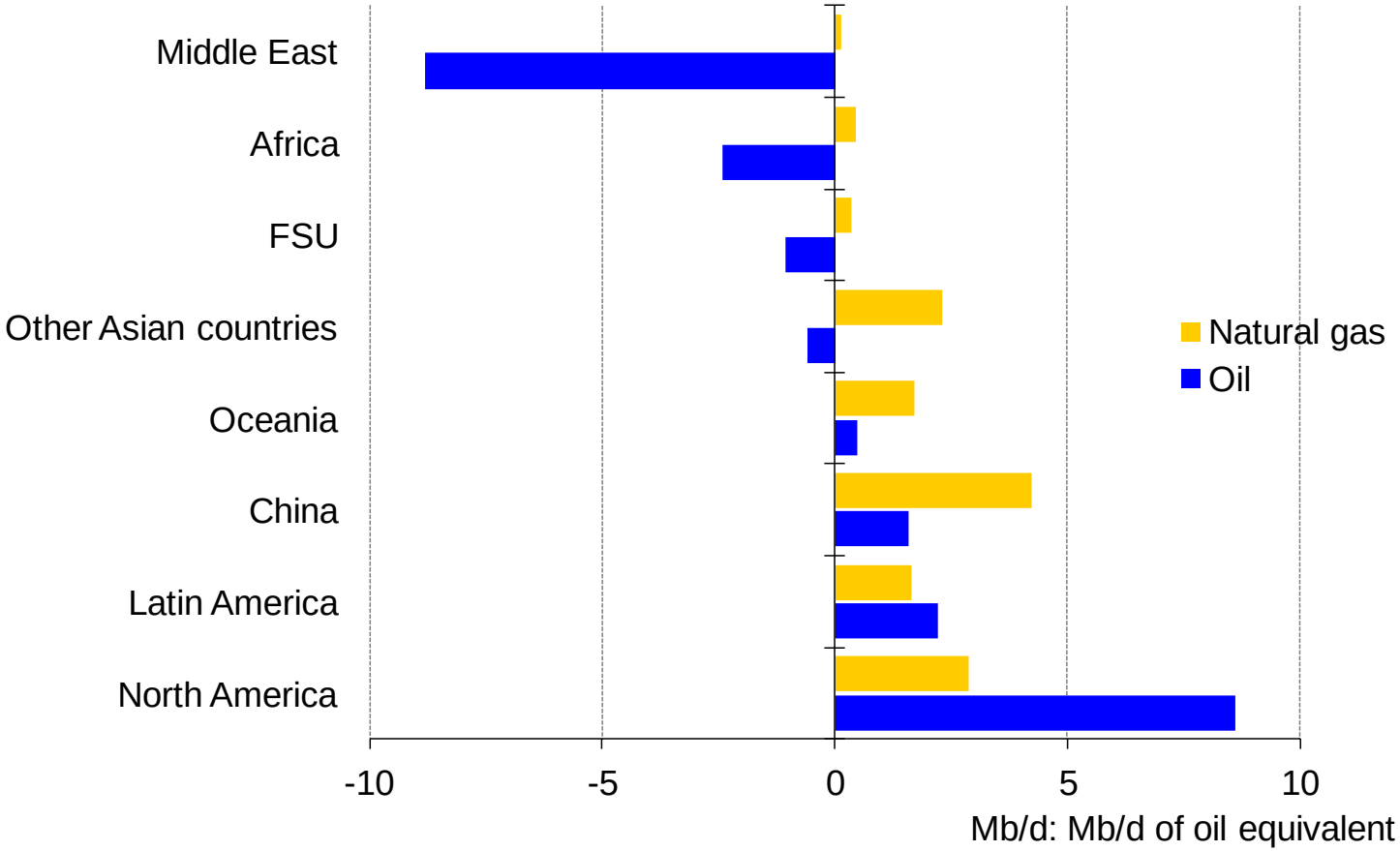
Share of global export market for energy-intensive goods



Source: IEA, World Energy Outlook 2013

Changes in Oil/Natural Gas Output

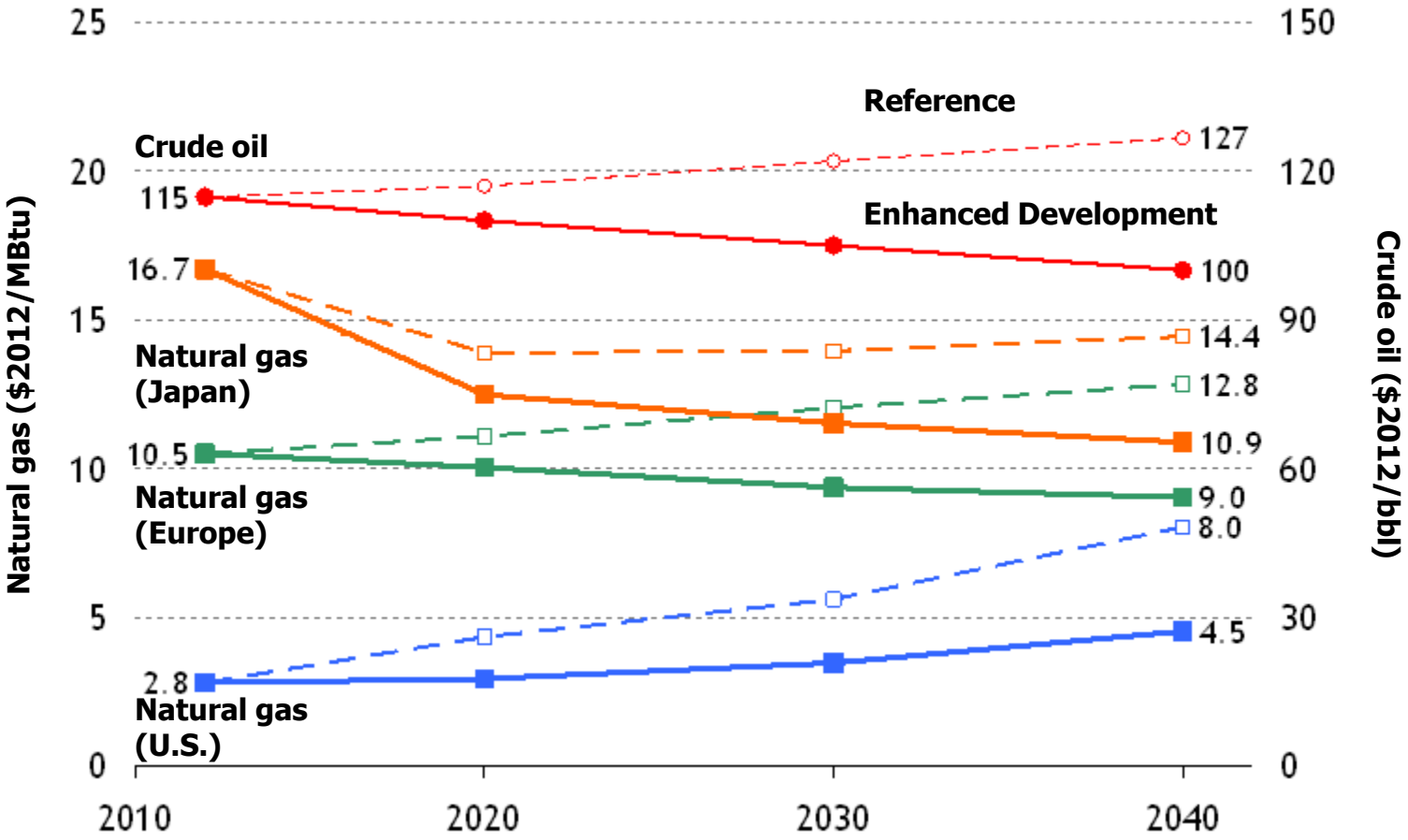
2040 Changes in the Enhanced Development Scenario from the Reference Scenario



Source: IEEJ (Asia/World Energy Outlook 2013)

Assumed Crude Oil/Natural Gas Prices

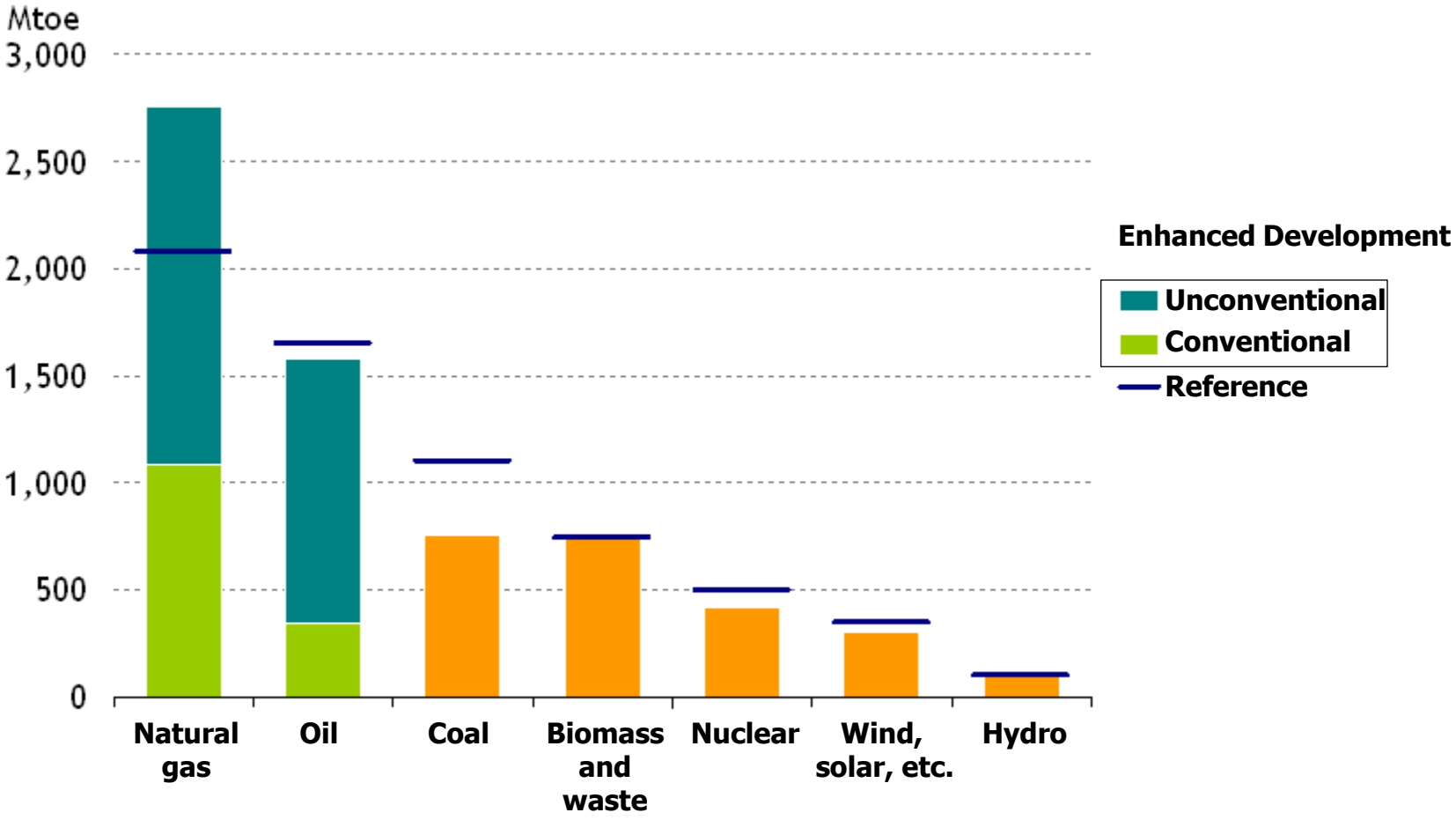
Enhanced Development and Reference Scenarios



Source: IEEJ (Asia/World Energy Outlook 2013)

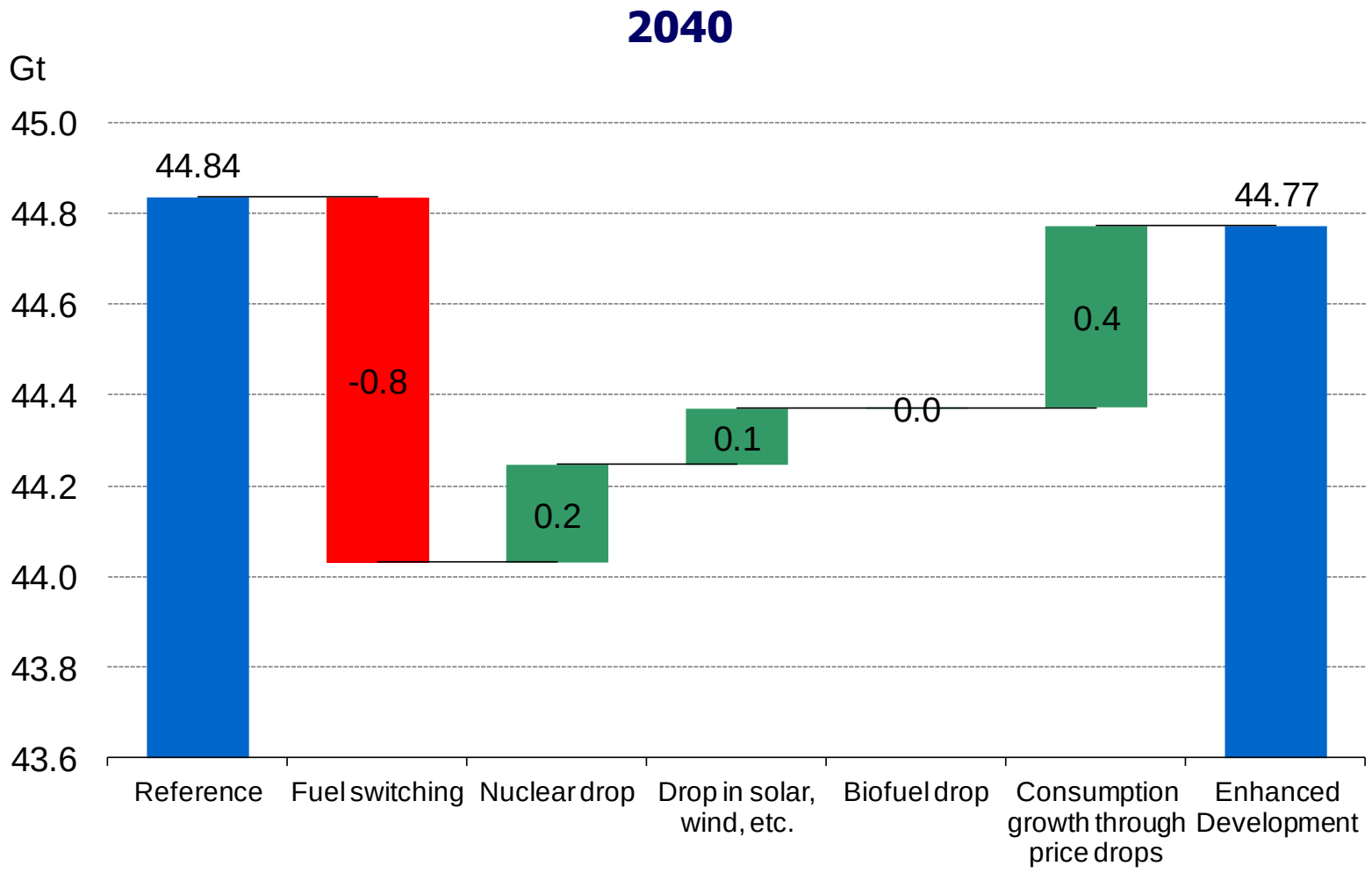
Primary Energy Consumption Growth

2011-2040 in the Enhanced Development Scenario



Source: IEEJ (Asia/World Energy Outlook 2013)

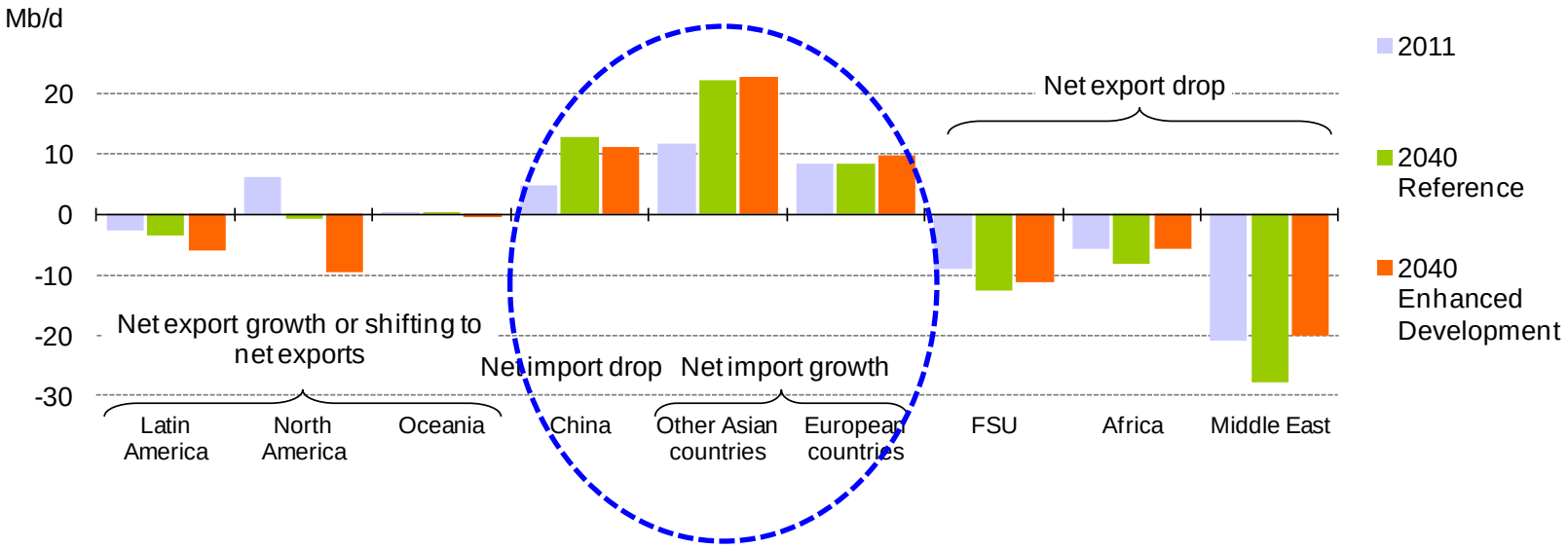
Energy-related CO_2 Emissions



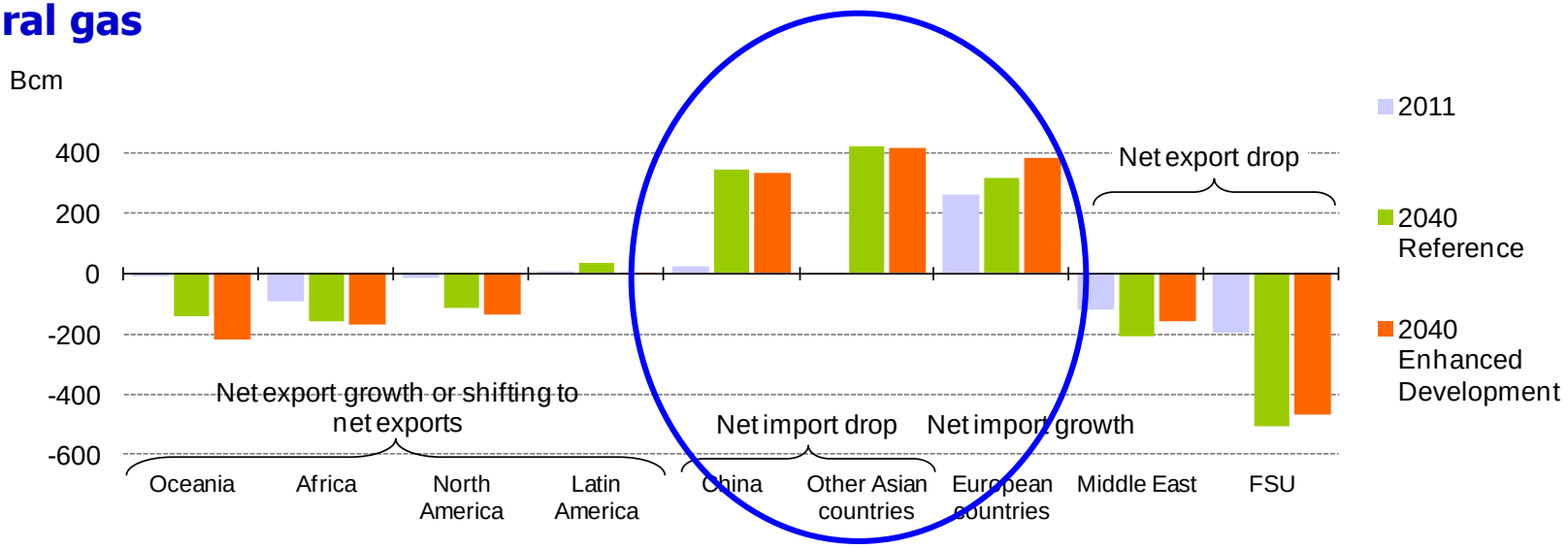
Source: IEEJ (Asia/World Energy Outlook 2013)

Changes in Net Oil/Natural Gas Imports

Oil



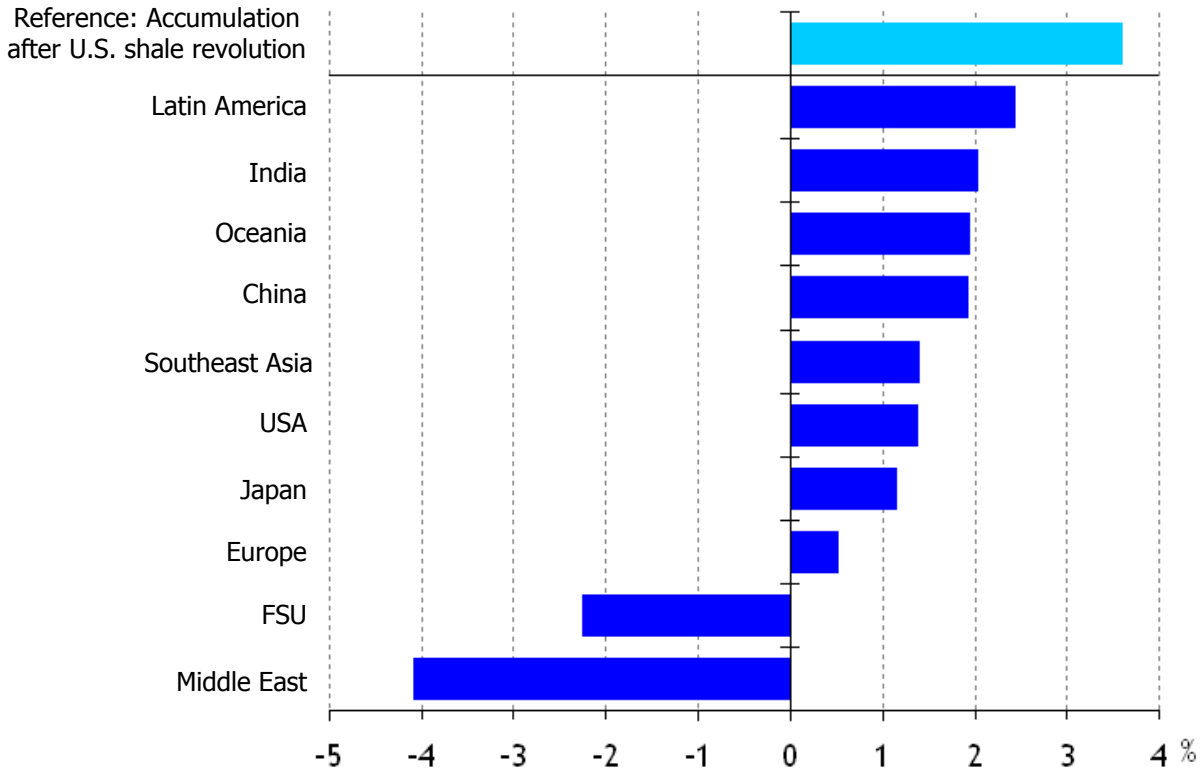
Natural gas



Source: IEEJ (Asia/World Energy Outlook 2013)

Impact on Real GDP

Changes in 2040 from the Reference Scenario



Note: Effects of a shift from the Reference Scenario to the Enhanced Development Scenario

Source: IEEJ (Asia/World Energy Outlook 2013)

Conclusion

Enhanced unconventional energy resources development

- The expansion of unconventional natural gas production will lower prices and as such, promote fuel switching from all other energy sources to natural gas as well as growth in natural gas consumption. The deceleration of nuclear and renewable energy power plant development also limit the CO_2 emission cut to a very small level.
- Progress in the development of unconventional resources including shale gas and oil will benefit most of the world economies, facilitating the energy supply-demand balance and dropping prices.
- A net fossil fuel export increase will have a great impact on the Americas. Net importers including China will benefit from slower import value growth. Japan will expand natural gas imports in volume while reducing them in value thanks to price drops. Japan will also economically benefit from export growth in line with greater global economic growth.

Energy conservation and climate change measures (CO_2 emission reduction)

- The maximum promotion of energy conservation and non-fossil energy introduction is required to address climate change issues. Reducing fossil fuel consumption through conservation measures will lower CO_2 emissions and stabilize energy supply markets.
- The maximum promotion of existing energy conservation and climate change measures and the introduction of CCS technologies will allow energy-related CO_2 emissions in 2050 to be cut by 20% from 2011. But the target of halving emissions by 2050 will fail to be attained.
- It would be difficult to reduce the atmospheric concentration of greenhouse gases to 450 ppm (CO_2 equivalent) by the end of the 21st century. However, it will still be possible. To substantially reduce CO_2 emissions, innovative technologies including bioenergy with CCS (BECCS) and carbon capture and use (CCU) technologies like artificial photosynthesis will have to be developed and diffused.

Toward developing future energy systems

- Global energy consumption will increase 1.5-fold over the next 30 years. Particularly, Asia will remarkably expand energy demand and raise its import dependence rate, increasing its presence as an energy consumer in the international energy market.
- How to use energy is greatly changing due to progress in unconventional resources development and non-fossil energy promotion trends. Nevertheless, pursuing objectives such as the Three Es plus S (energy security, environmental protection and economic efficiency plus security) remain important.
- Japan can play great roles in leading the world and Asia to achieve sustainable development. Japan must further enhance energy conservation and low-carbon technologies (including renewable and nuclear energy technologies and their security) to meet the needs and expand their deployment.

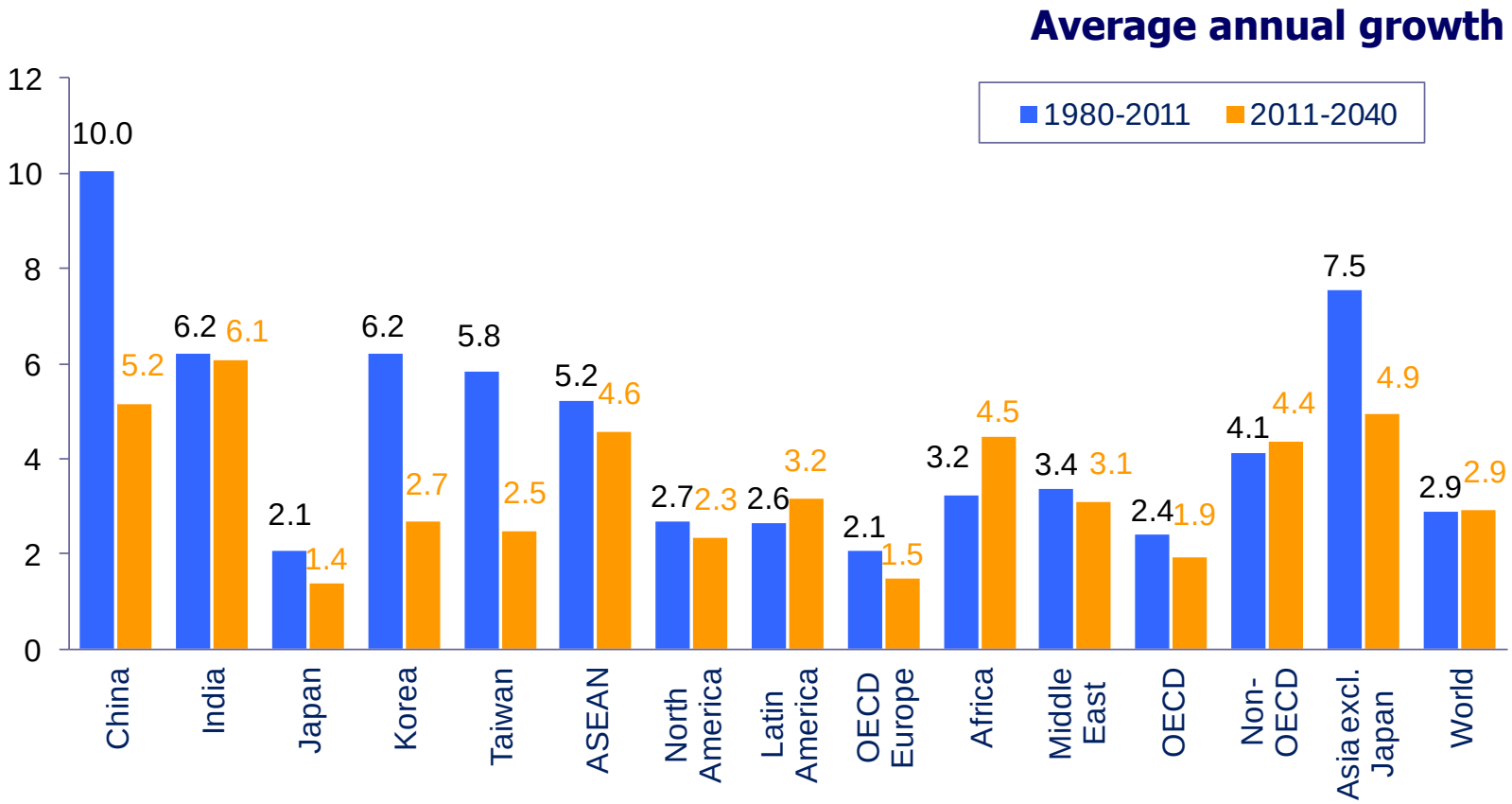
Thank you very much for your attention!

Summary and PPT available on IEEJ website!

http://eneken.ieej.or.jp/en/whatsnew/413.html

Asia / World Energy Outlook 2013

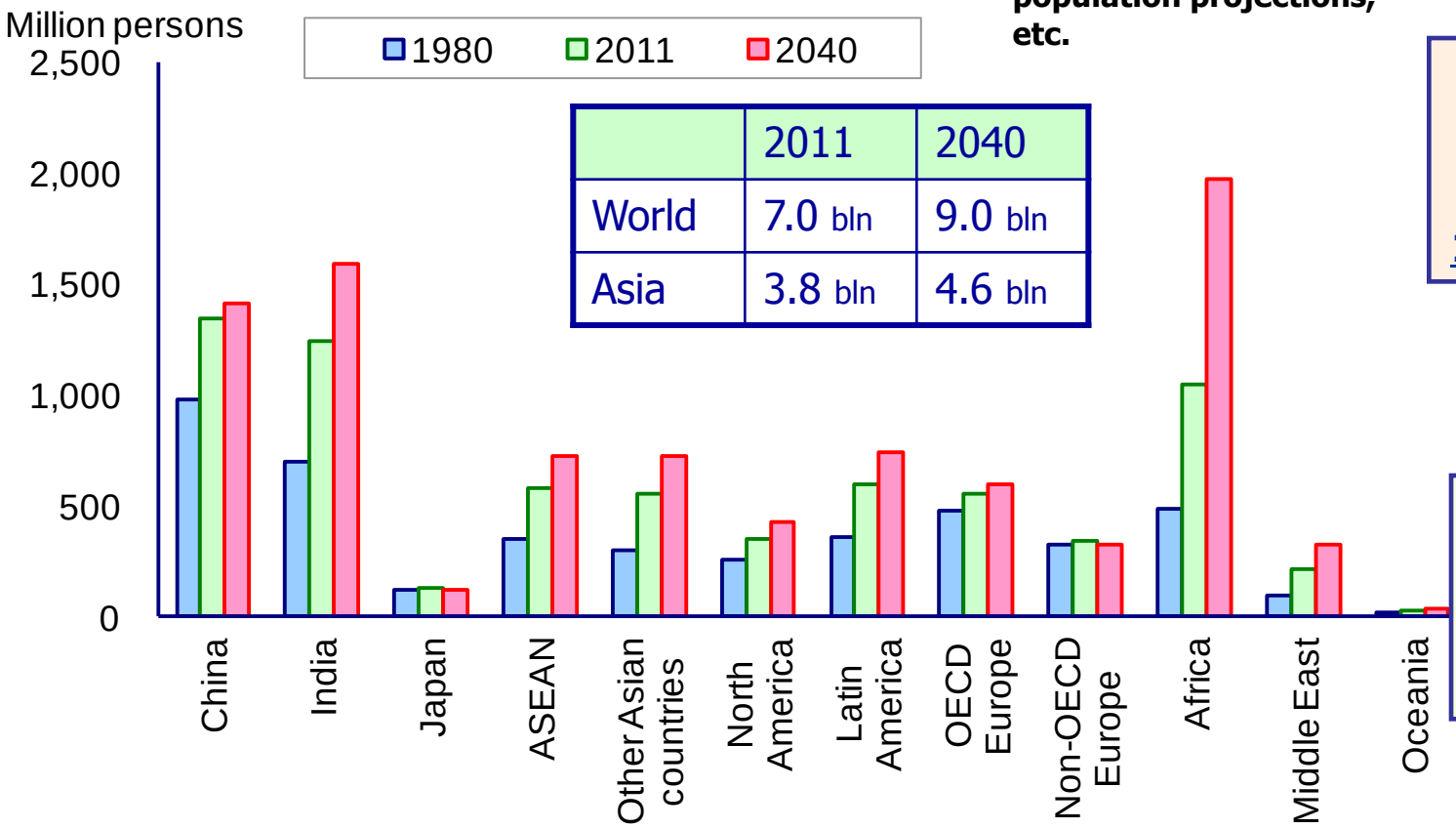
Major Assumptions: Gross Domestic Product



- **The overall world economy is assumed to continue to grow steadily over the medium to long term by almost 3%.**
- **China's economic growth is anticipated to decelerate over time, primarily reflecting a decline in its currently abundant working population.**
- **Meanwhile, India and ASEAN countries with younger populations, are expected to benefit from a growing labor force and will achieve higher economic growth through 2040.**

Major Assumptions: Population

＊Prepared based on U.N. population projections, etc.



	2011	2040
World	7.0 bln	9.0 bln
Asia	3.8 bln	4.6 bln

China

2011
1.34 bln
↓
2040
1.41 bln (Up 0.07)

India

2011
1.24 bln
↓
2040
1.59 bln (Up 0.35)

- **Population is expected to increase mainly in developing (non-OECD) countries.**
- **China's population will gradually age and peak out around 2030. Meanwhile, population will rapidly increase in India and Africa, thanks to medical technology and food nutrition improvement.**
- **India will replace China as the most populated country in Asia (and the world) around 2025; population should reach 1.59 billion in 2040.**

Source: IEEJ (Asia/World Energy Outlook 2013)

Advanced Technology Scenario Assumptions

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

Introducing and Enhancing Environmental Regulations and National Targets	Promoting Technology Development and International Technology Cooperation
Environment Tax, Emissions Trading, RPS, Subsidy Provisions, FIT, Efficiency Standards, Automobile Fuel Efficiency Standard, Low Carbon Fuel Standard, Energy Efficiency Labeling, National Targets, etc.	R&D Investment Expansion, International Cooperation on Energy Efficient Technology (steelmaking, cement and other areas), Support for Establishing Energy Efficiency Standards, etc.

【Demand Side Technology】

■ Industry

Under sectoral and other approaches, best available technologies on industrial processes (for steelmaking, cement, paper-pulp and oil refining) will be deployed globally

■ Transport

Clean energy vehicles (highly fuel efficient vehicles, hybrid vehicles, plug-in hybrid vehicles, electric vehicles, fuel cell vehicles) will diffuse further.

■ Building

Efficient electric appliances (refrigerators, TVs, etc.), highly efficient water-heating systems (heat pumps, etc.), efficient air conditioning systems and efficient lighting will diffuse further, with heat insulation enhanced.

【Supply Side Technology】

■ Renewable Energy

Wind power generation, photovoltaic power generation, CSP (Concentrated Solar Power) generation, biomass power generation and bio-fuel will diffuse further.

■ Nuclear Energy Promotion

Nuclear power plant construction will be accelerated with operating rates improved.

■ Highly Efficient Fossil-fired Power Plant Technology

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

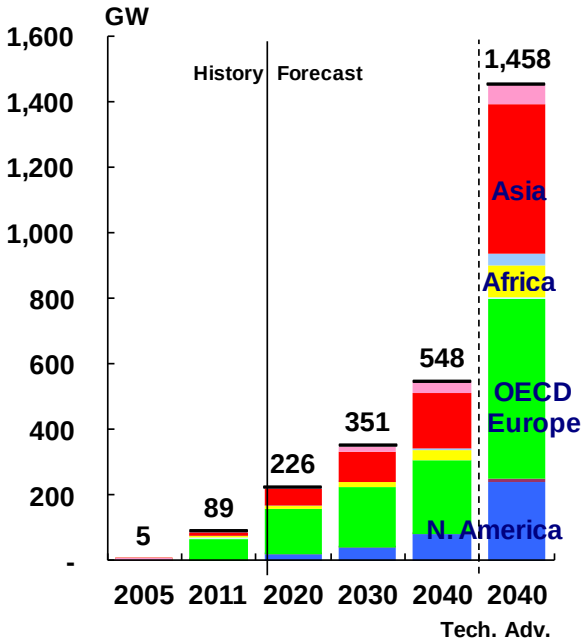
■ CCS

CCS deployment will expand in the power generation sector (new and old coal-fired and gas-fired plants) and the industrial sector (steelmaking, cement and other plants that emit massive GHGs).

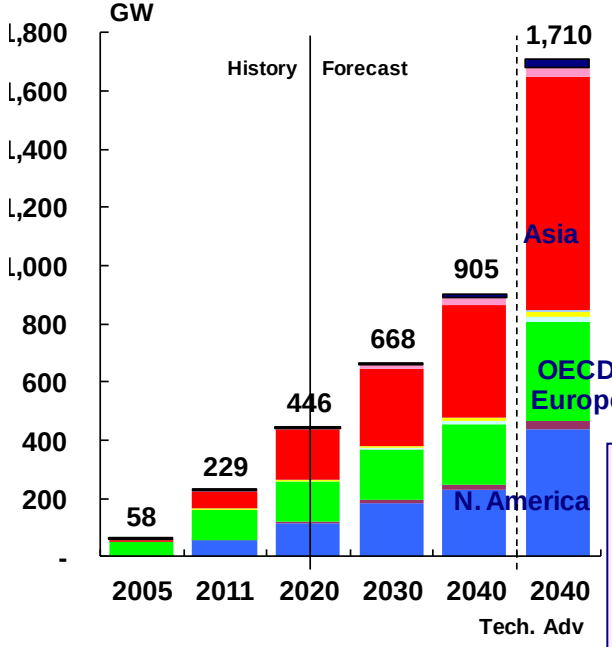
Source: IEEJ (Asia/World Energy Outlook 2013)

Photovoltaic and Wind Power Generation (World)

Photovoltaic (PV)



Wind Power



Photovoltaic (PV)

World

2011
89 GW
↓
2040
Ref. Tech. 548 GW
Adv. Tech. 1,458GW
(Up 6-fold) (Up 16-fold)

Asia

2011
9.0GW
↓
2040
Ref. Tech. 172 GW
Adv. 453GW
(Up 19-fold) (Up 50-fold)

Wind Power

World

2011
229 GW
↓
2040
Ref. Tech. 905 GW
Adv. 1,710GW
(Up 4-fold) (Up 7-fold)

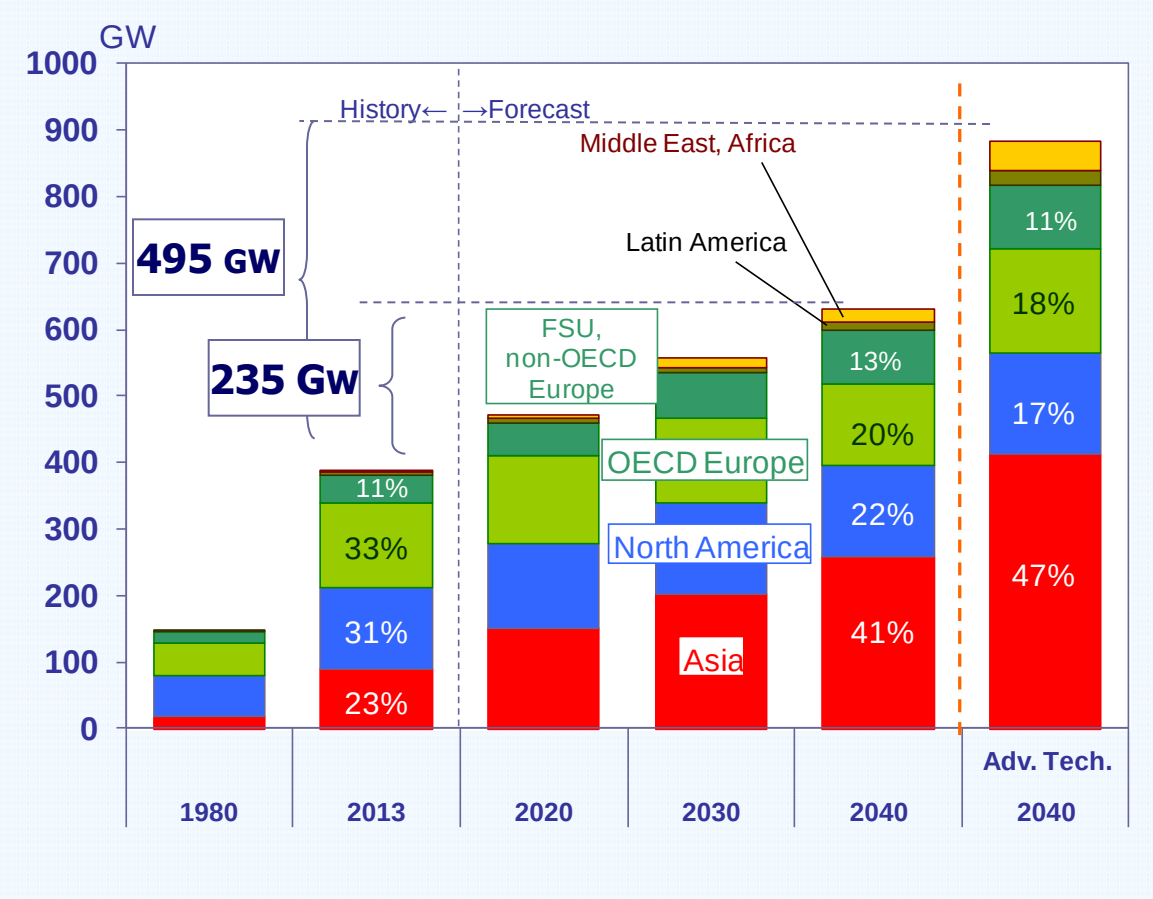
Asia

2011
61 GW
↓
2040
Ref. Tech. 390 GW
Adv. 801GW
(Up 6-fold) (Up 13-fold)

- Renewable energy power generation will expand due to technological development and supportive measures such as feed-in tariff systems and subsidization.
- In the Reference Scenario, global photovoltaic generation capacity will expand six-fold from 2011 to 548 GW in 2040 and wind power generation capacity will increase four-fold from 2011 to 905 GW in 2040. Photovoltaic and wind power generation's share of global generation will increase from 2.3% in 2011 to 5.9% in 2040.
- In the Advanced Technology Scenario, photovoltaic power generation capacity in 2040 will be 2.7-fold more than in the Reference Scenario, standing at 1,458 GW. Wind power generation capacity will be 1.9-fold more at 1,710 GW.

Source: IEEJ (Asia/World Energy Outlook 2013)

Global Nuclear Power Generation Capacity



World

2013

389 GW

↓

2040

Reference

624 GW (Up 235 GW)

Adv. Tech.

885 GW (Up 495 GW)

- **Global nuclear power generation capacity in 2040 will grow by 235 GW in the Reference Scenario and by 495 GW in the Advanced Technology Scenario. Asia will lead the growth and account for nearly half of the global capacity in 2040 in the Advanced Technology Scenario.**

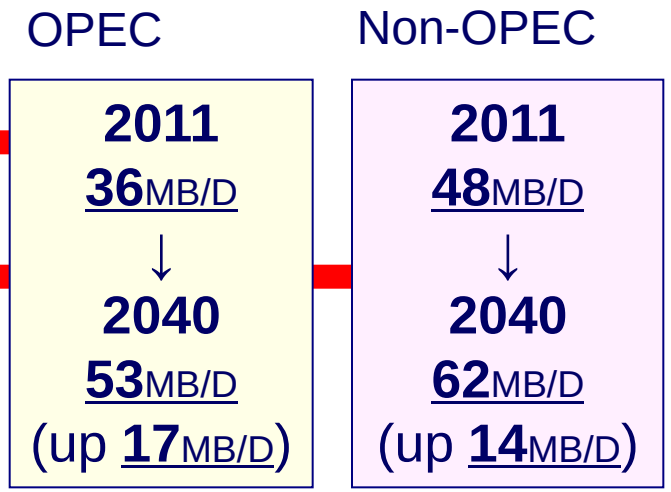
Source: IEEJ (Asia/World Energy Outlook 2013)

Oil Production Outlook

Reference
Enhanced Scenario

Mb/d

	2011	2030	2040	2011-40 (%)
OPEC	36	46	53	1.4
Middle East OPEC	26	33	38	1.3
Non-Middle East OPEC	10	14	15	1.7
Non-OPEC	48	59	62	0.9
North America	12	17	17	1.4
Latin America	7	10	11	1.4
EU, Eurasia	17	19	21	0.6
Middle East	2	2	2	0.0
Africa	2	3	3	0.7
Asia	8	8	8	0.1
China	4	4	5	0.5
Indonesia	1	1	1	0.3
India	1	1	1	-1.1
Oceania	1	1	1	2.4
Process Gain	2	3	3	1.7
World Total (Reference)	86	108	119	1.1
World Total (Enhanced Scenario)		107	117	1.1



Share in Increase of Global Oil Production

OPEC 54% (up 17MB/D)

Non-OPEC 41% (up 14MB/D)

- **More than half of the increase in global oil demand will be supplied by OPEC production. OPEC share will increase to 45% by 2040.**
- **Middle East is facing domestic oil demand increases. If the efforts towards more efficient use of energy or swift investment to add production capacity are delayed, global oil demand and supply balance will be tightening in the future.**

Source: IEEJ (Asia/World Energy Outlook 2013)

Gas Production Outlook

Reference

Bcm

	2011 Actual			2040 Reference Scenario		
		of which Unconventional	Share of Unconventional (%)		of which Unconventional	Share of Unconventional (%)
North America	808	364	45%	1,043	782	75%
Latin America	218	0	0%	449	127	28%
Middle East	523	0	0%	871	24	3%
EU	287	0	0%	300	19	6%
CIS	868	0	0%	1,229	66	5%
Africa	200	0	0%	420	80	19%
China	103	0	0%	352	127	36%
India	46	0	0%	96	29	30%
Asean	203	0	0%	385	80	21%
Indonesia	81	0	0%	126	22	17%
Malaysia	56	0	0%	85	8	10%
Other Asia	75	0	0%	74	5	6%
Australia	51	6	12%	193	103	53%
World Total	3,384	370	11%	5,411	1,442	27%

2040: Gas Production
5,411Bcm
Increase from 2011
2,017 Bcm

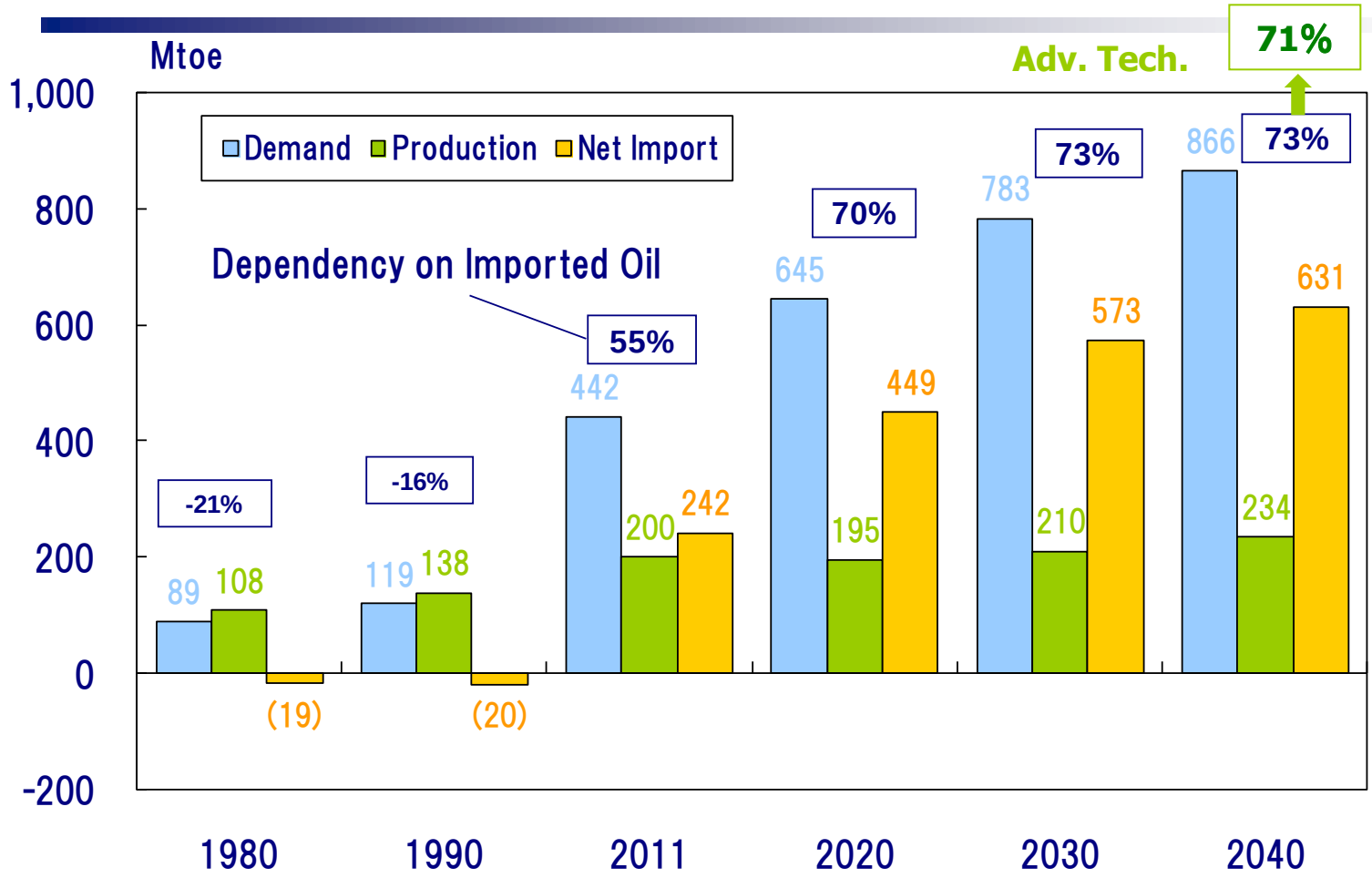
Share in increase
Middle East & CIS
35%
America
23%

Unconventional Share
Year 2011
11%
↓
Year 2040
27%

- To meet the increasing demand for natural gas, 2/3 of the production increase will come from the Middle East, CIS, Africa, China and Australia.
- Commercial production of unconventional natural gas including shale gas will increase in Argentina, Mexico, Middle East and CIS. The share of unconventional gas in natural gas production will reach 25% by 2040.

Source: IEEJ (Asia/World Energy Outlook 2013)

Oil Demand and Supply in China



Net Oil Import

2011
5.0MB/D
↓
2040
Reference
12.9MB/D
(**2.6**times)

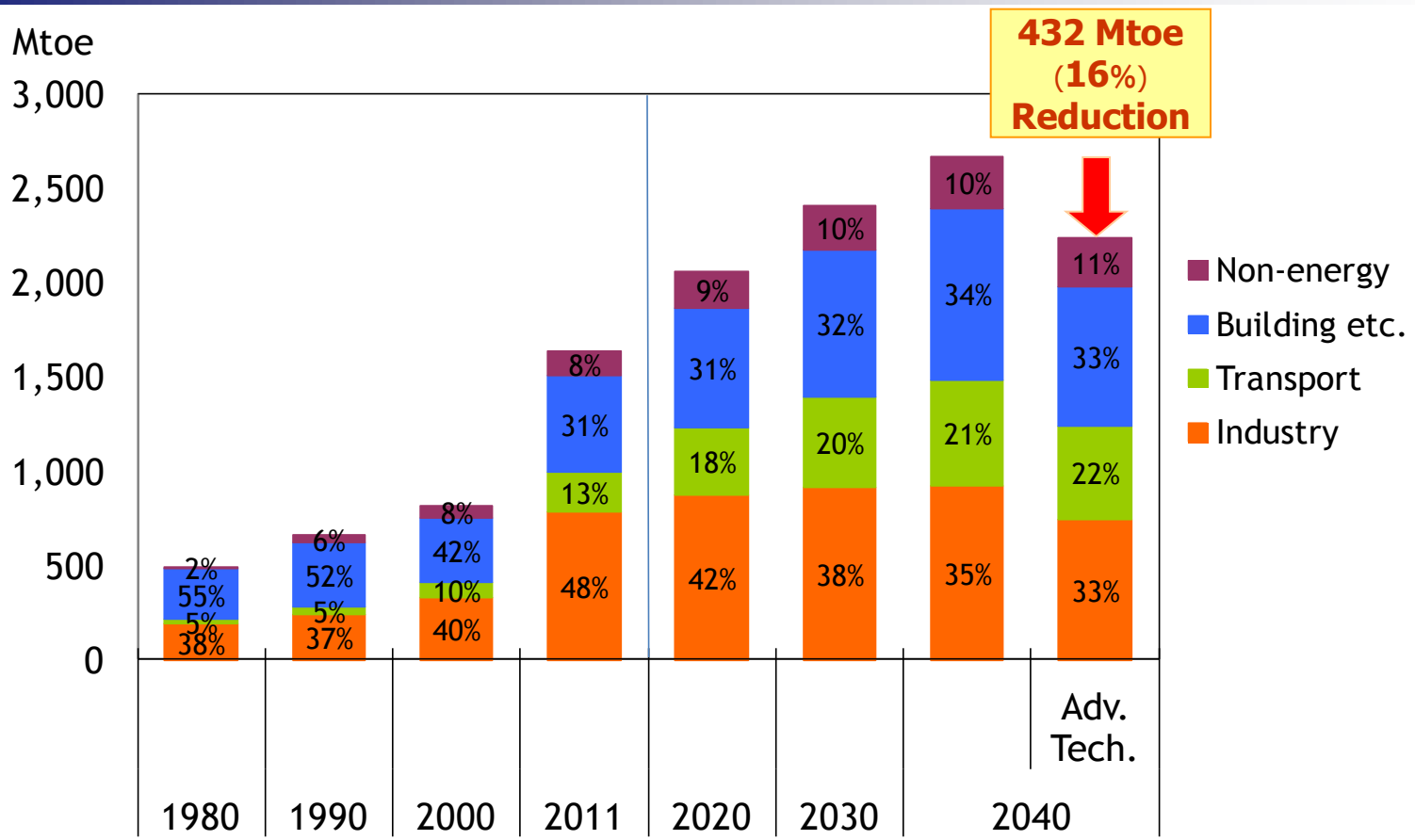
Adv. Tech.
10.1MB/D
(**2.0**times)

- Net oil import is projected to expand from 242 million ton (5.0mb/d) in 2011 to 631million ton (12.9 mb/d) in 2040. As a result, net oil import ratio will reach 73% in 2040 from 55% in 2011.
- In the Adv. Tech. Scenario, oil demand will grow at a relatively slow rate, but net oil import ratio will still increase to 71% in 2040.
- In order to sustain domestic oil production, continued investments are required to explore and develop oil fields in the western part of China and offshore.

Source: IEEJ (Asia/World Energy Outlook 2013)

Final Energy Demand in China

Reference
Adv. Tech.

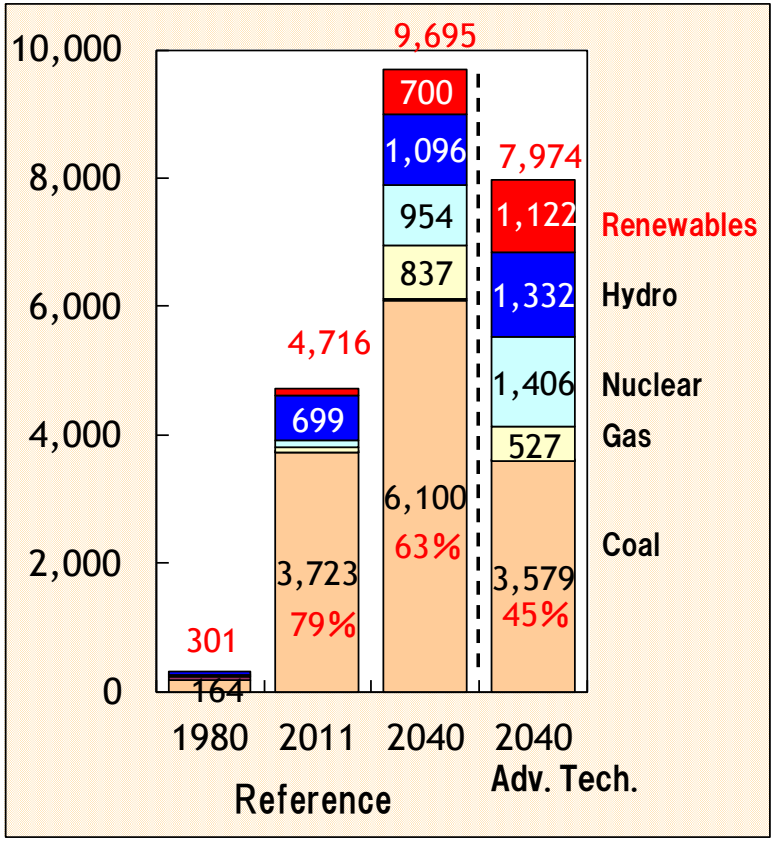


- Energy demand of heavy industry which has been strong up to now will grow relatively slowly in the future.
- By contrast, energy demand of the household, buildings, and transport sectors will increase substantially. Although the share of the household and commercial sectors will reach 34% in 2040 (from 31% in 2011) , the per capita energy demand of those sectors will still be lower than the OECD average.
- In the Tech. adv. Scenario, energy demand of the household, building, and transport sectors is expected to have big potential for reduction.

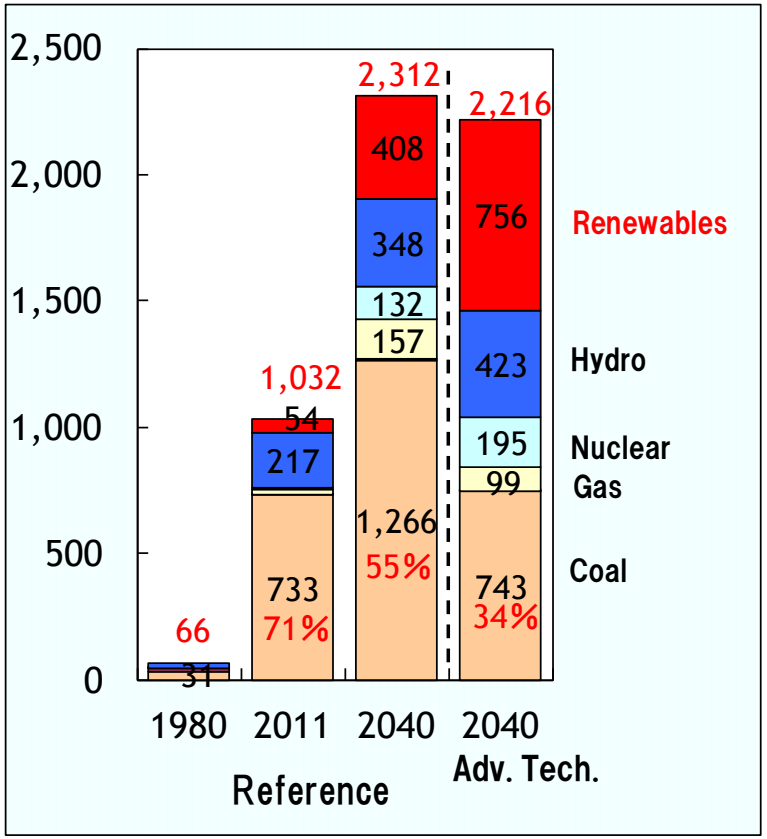
Source: IEEJ (Asia/World Energy Outlook 2013)

Power Generation Sector (China)

【Power Generation (TWh)】



【Capacity (GW)】



■ Total power generation capacity will increase on average by 44 GW per year, from 1,032 GW in 2010 to 2,312 GW in 2040. The share of coal-fired power plant will gradually decline to 55% in 2040, still representing almost half of the world coal-fired power generation capacity.

■ Total power generation will more than double, increasing from 4,716 TWh in 2011 to 9,695TWh in 2040. Power generation from gas-fired, nuclear and renewables will substantially increase, while hydro power will represent moderate growth. The share of coal-fired will decline from 79% in 2011 to 63% in 2040.

■In the Adv. Tech. Scenario, generation from nuclear, hydro and renewable energy will sharply expand to substitute a further decline in coal-fired generation.

Source: IEEJ (Asia/World Energy Outlook 2013)

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