Energy Mix in Japan and Its Implication on Energy Mix in India

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The Institute of Energy Economics, Japan (IEEJ)

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1. Energy mix in Japan (Tech. Ad. Scenario; July 2015)
(1) Basic policy direction

1) Policy standpoints for long-term energy supply/demand outlook

⇒ The outlook provides a desirable future picture of energy supply and demand to be realized through measures implemented for the policy targets for energy security (stable supply), economic efficiency(energy cost), environmental friendliness and safety (**3E+S**) based on the Basic Energy Plan which was approved at Cabinet Meeting in April 2014. This time, an outlook for 2030 is being developed.

2) Policy goals on energy mix formulation

① The energy self-sufficiency rate should be higher than before the March 2011 Great East Japan Earthquake (around 25%).

② Electricity costs should be lowered from the present levels.

③ The greenhouse gas emission reduction target should be comparable to major economies , such as EU and the US levels. Japan need to take global leadership in cutting emissions.

⇒ At the same time, Japan should reduce its dependence on nuclear power generation as far as possible.

3) Regular revision

⇒ The energy mix should be revised as necessary at least to meet the Basic Energy Plan review coming every 3 years.

1. Energy mix in Japan (Tech. Ad. Scenario; July 2015)
(2) Promotion of Energy Conservation

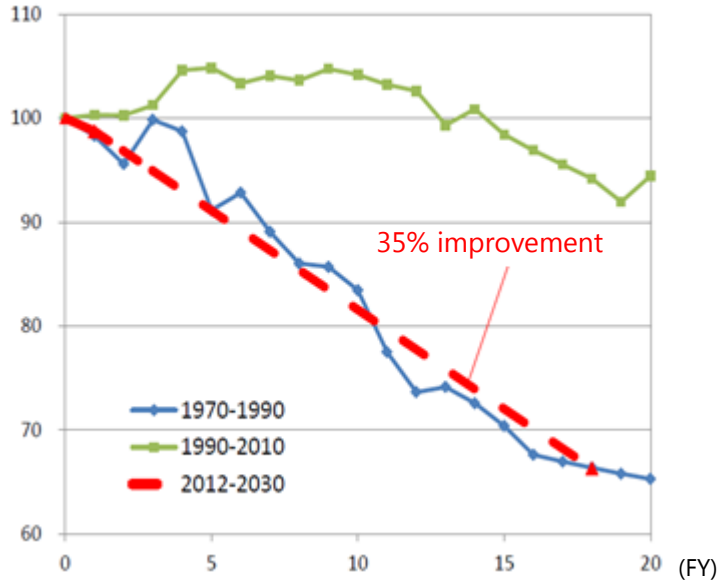
- Thorough energy conservation measures would reduce final energy consumption by 13% to 326 million kl.
- Energy conservation measures would be accumulated to improve energy efficiency as much as just after the oil crises.

Electricity demand (100 million kWh)

	FY2013		FY2030			
			Reference		Energy conservation	
Industry	3,126	32%	4,284	36%	3,824	39%
Commerce	3,509	36%	4,387	37%	3,444	35%
Residential	2,852	30%	2,909	25%	2,308	24%
Transport	179	2%	189	2%	232	2%
Total	9,666	100%	11,769	100%	9,808	100%

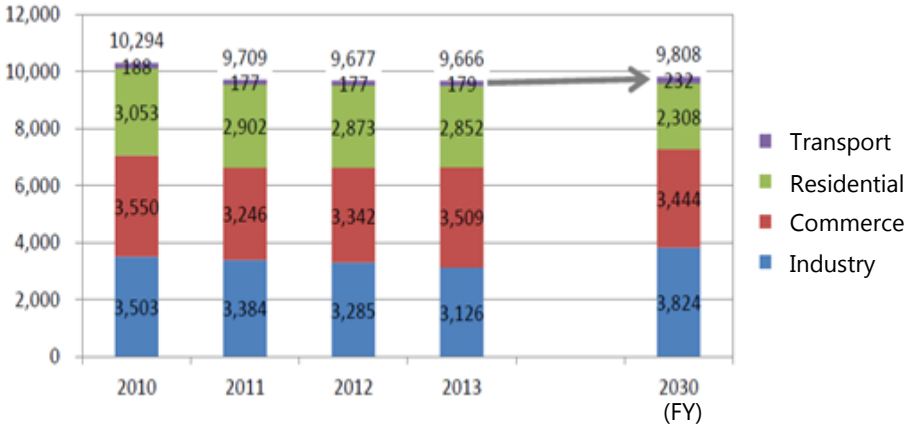
※Numbers for FY2030 are estimates.

【Energy efficiency improvement】



Energy efficiency=final energy consumption/real GDP

Changes in electricity demand (100 million kWh)

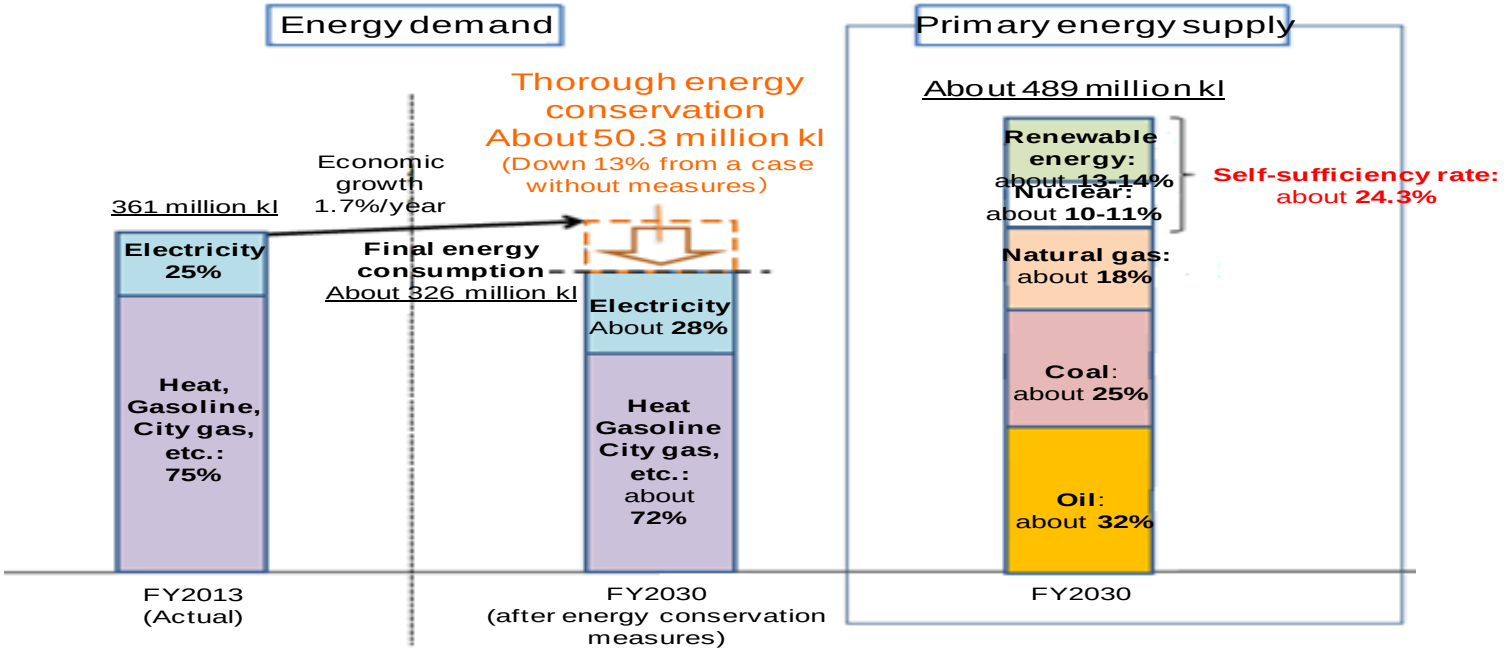


(Source) Document 3 "Long-term Energy Supply/Demand Outlook, Related Documents" p.66 (left chart) and p.69 (right chart) at 11th meeting (July 16, 2015) of the Long-term Energy Supply and Demand Outlook Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy

1. Energy mix in Japan (Tech. Ad. Scenario; July 2015)
(3) Energy supply/demand structure in 2030 <I> Primary energy

<1> Energy demand and primary energy supply structure

- ○ While energy demand growth is projected in line with economic growth (**an average 1.7%**), energy efficiency is expected to improve as much as after the oil crises thorough energy conservation (**35% in 20 years**).
- ○ Energy supply/demand structure improvement (energy self-sufficiency rate: 6% in 2014 ⇒**24.3%** in 2030)
- ○ Energy-related CO_2 emissions: **down 21.9%** from 2013



(Source) METI "Long-term Energy Supply/Demand Outlook" p.5 (July 16, 2015)

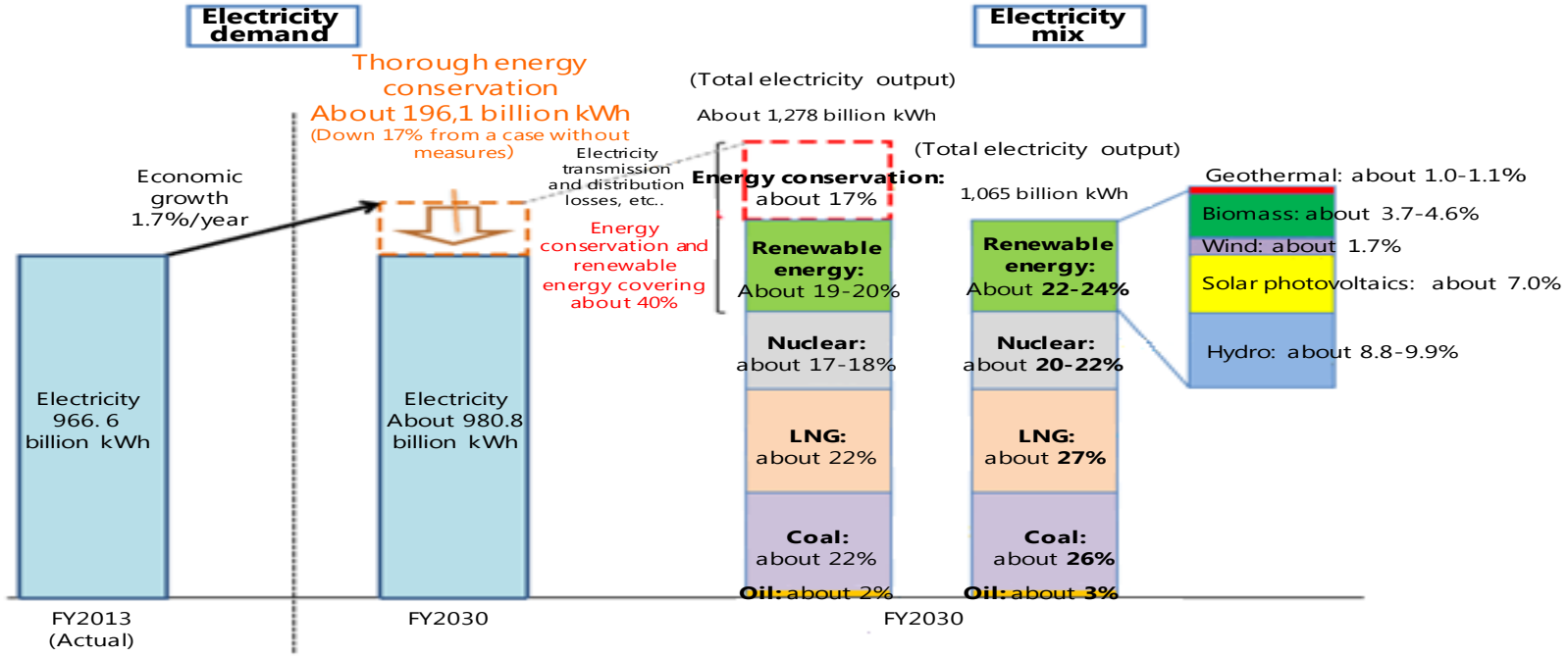
1. Energy mix in Japan (Tech. Ad. Scenario; July 2015)
(3) Energy supply/demand structure in 2030 <II> Electricity mix

<2> Electricity mix

○Thorough energy conservation (electricity savings) and the maximum renewable energy diffusion will cover **about 40%** of electricity demand, reducing the dependence on nuclear power generation substantially (from **29%** before the 3/11 disaster to **20-22%**).

○ Base load share: **56%** (**63%** before the 3/11 disaster)

○ Electricity costs to **decline by 2-5%** from the present level



(Source) METI "Long-term Energy Supply/Demand Outlook" p.7 (July 16, 2015)

1. Energy mix in Japan (Tech. Ad. Scenario; July 2015)
(4) Comparison of major countries' Intended Nationally Determined Contributions

	From **1990**	From **2005**	From **2013**	GHG emissions per GDP (kg/dollar GDP)	
				2012 Actual	2025/2030 Estimated
Japan **(2030)**	▲18.0%	▲25.4%	**▲26.0%**	0.28	0.1 6
U.S. **(2025)**	▲14-16%	**▲26-28%**	▲18-21%	0.45	0.27-0.28
EU **(2030)**	**▲40%**	▲35%	▲24%	0.31	0.17

■ The U.S. submitted a reduction target compared with 2005 and the EU a target compared with 1990.

(Source) Reference Document 1 "Draft Commitment-related Materials" p.3-4 at 7th joint meeting (April 30, 2015) of the subcommittee on post-2020 global warming measures, Global Environment Subcommittee, Central Environment Council, and the working group on intended nationally determined contributions, Global Environment Subcommittee, Committee on Industrial Science and Technology Policy and Environment, Industrial Structure Council

Cost Comparison in Power Source

Overview of 2030 model plant estimation results and sensitivity analyses

Power sources	Nuclear	Coal	LNG	Wind (Onshore)	Wind (Offshore)	Geothermal	Ordinary hydro	Small hydro 800,000 yen/kW	Small hydro 1 million yen/kW	Biomass (Wood fuel)	Biomass (Mixed fuel)	Oil	Solar PV (Mega)	Solar PV (Housing)	Gas cogeneration	Oil cogeneration
Operating rate Service life	70% 40 years	70% 40years	70% 40years	20~23% 20years	30% 20years	83% 40years	45% 40years	60% 40 years	60% 40 years	87% 40 years	70% 40 years	30・10% 40years	14% 30years	12% 30years	70% 30years	40% 30years
Generation cost yen/kWh	10.3~ (8. 8~)	12. 9 (12. 9)	13. 4 (13. 4)	13. 6 ~21. 5 (9. 8 ~15. 6)	30. 3 ~34. 7 (20. 2 ~23. 2)	16. 8 (10. 9)	11. 0 (10. 8)	23. 3 (20. 4)	27. 1 (23. 6)	29. 7 (28. 1)	13. 2 (12. 9)	28. 9 ~41. 7 (28. 9~ 41. 6)	12. 7 ~15. 6 (11. 0~ 13. 4)	12. 5 ~16. 4 (12. 3~ 16. 2)	14. 4 ~15. 6 (14. 4~ 15. 6)	27. 1 ~31. 1 (27. 1~ 31. 1)
2011 Cost Review Committee report	8. 9~	10. 3	10. 9	8. 8~ 17. 3	8. 6~ 23. 1	9. 2~ 11. 6	10. 6	19. 1 ~22. 0	19. 1 ~22. 0	17. 4 ~32. 2	9. 5 ~9. 8	25. 1~ 38. 9	12. 1~ 26. 4	9. 9~ 20. 0	11. 5	19. 6

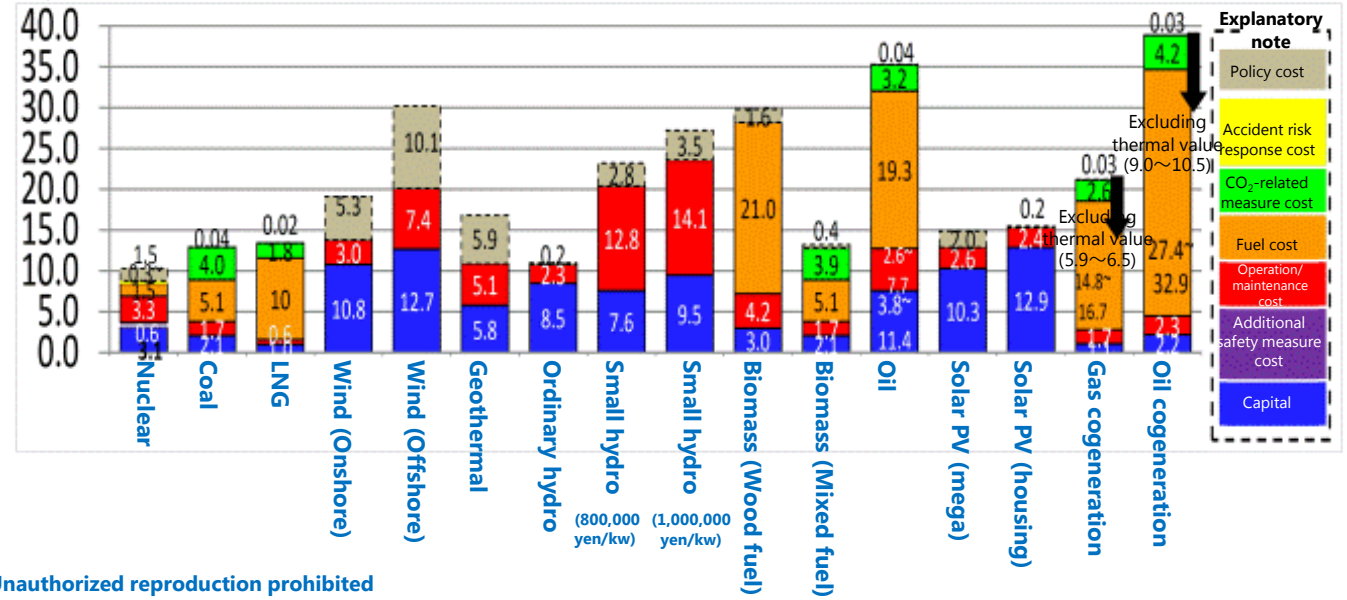
※1 Fossil fuel prices could drop depending on future policy efforts. Sensitivity analysis results follow:

Sensitivity analysis for fossil fuel power generation	Coal	LNG	Oil
Impact of a 10% fuel price change (yen/kWh)	About ±0.4	About ±0.9	About ±1.5

※2 The operating rate in 2011 stood at 80% for Coal and LNG and 50%/10% for Oil.

※3 Figures in parentheses represent costs excluding the policy cost.

Yen/kWh



<Adjustment costs accompanying penetration of naturally volatile power sources (solar PV and wind)>

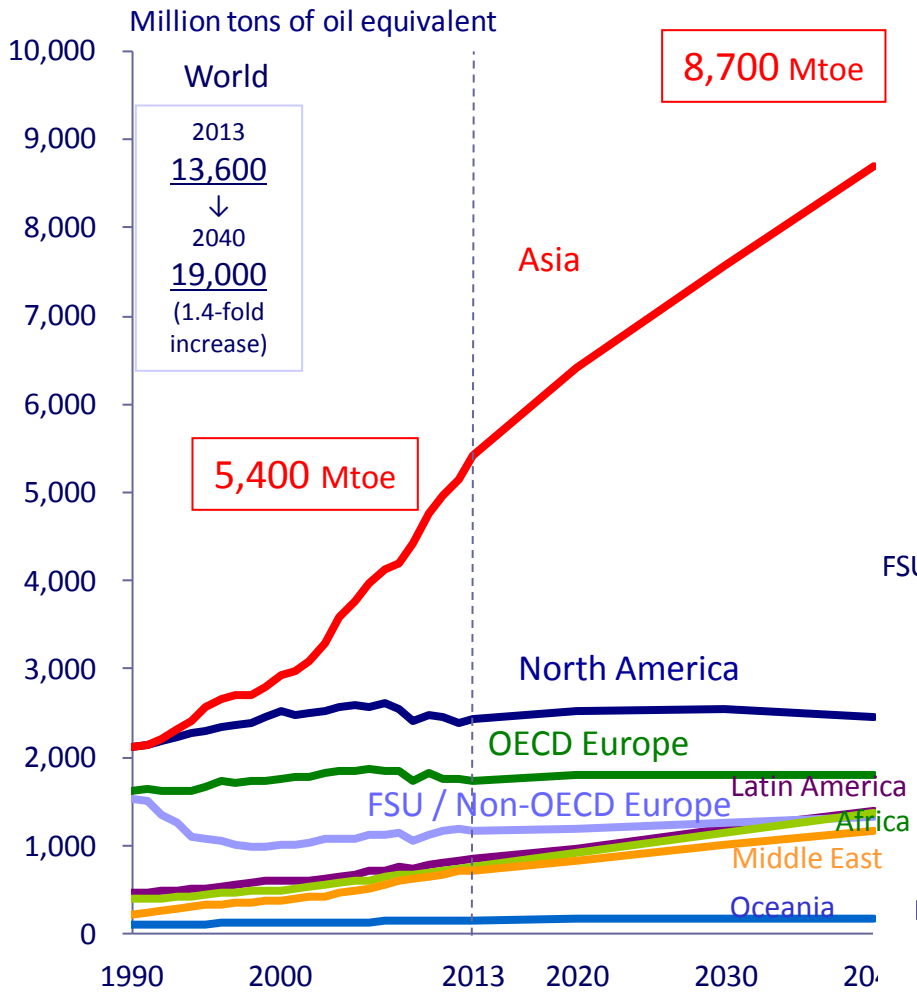
Penetration rate for naturally volatile power sources	Penetration rate for renewables	Survey cost
About 66 billion kWh (6%)	About 19-21%	About 300 billion yen/year
About 93 billion kWh (9%)	About 22-24%	About 470 billion yen/year
About 124 billion kWh (12%)	About 25-27%	About 700 billion yen/year

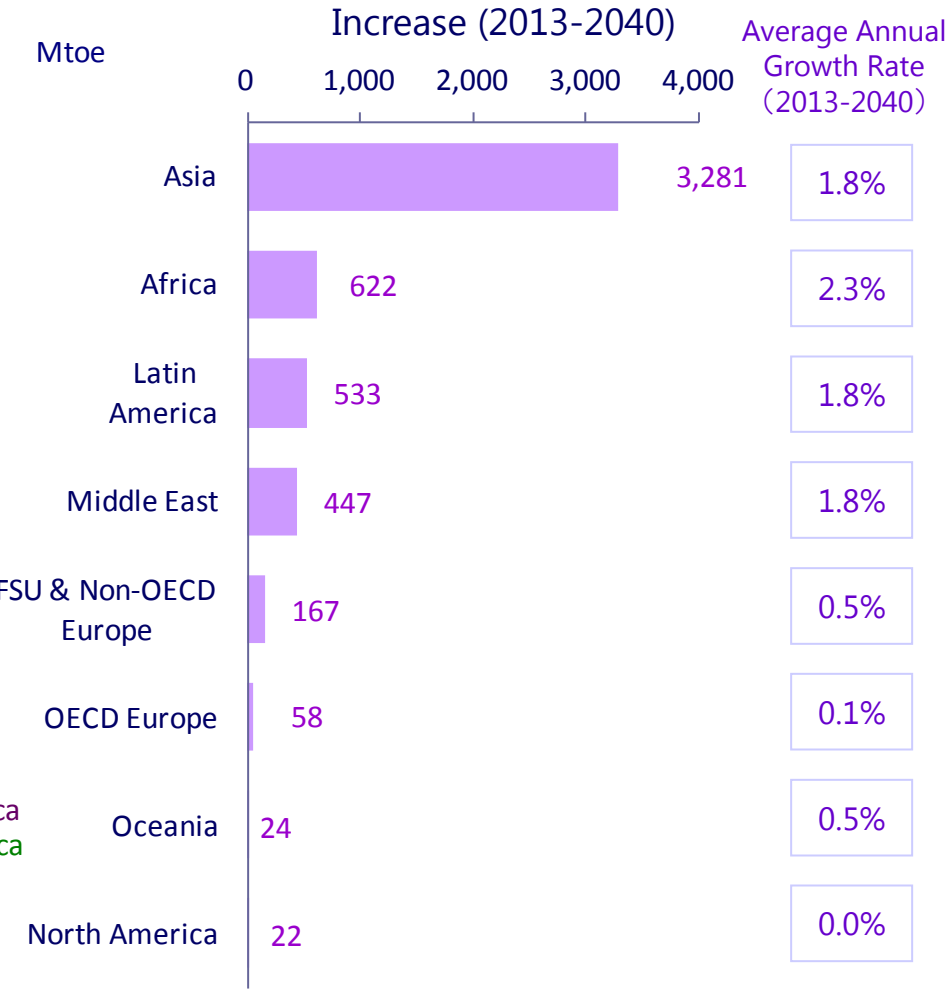
※Penetration rates are based on total power generation at 1,065 billion kWh .

(Source) Document 3 "Long-term Energy Supply/Demand Outlook, Related Documents" p.83 at 11th meeting (July 16, 2015) of the Long-term Energy Supply and Demand Outlook Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy

2. Primary Energy Consumption in the World
(1) Primary Energy Demand by Region

Reference Scenario

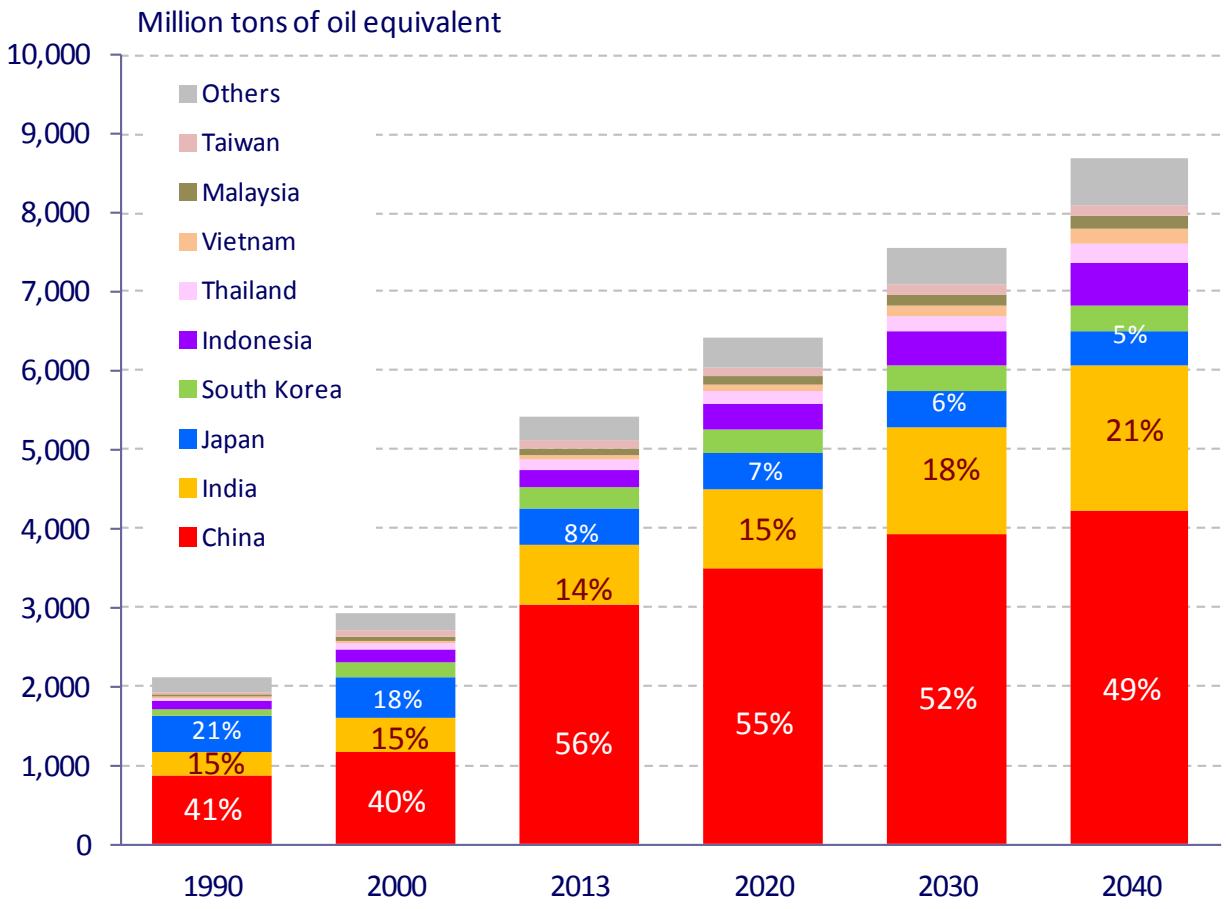




(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

2. Primary Energy Consumption in the World
(2) Primary Energy Consumption in Asia

Reference Scenario



Asia

2013
5,400
↓
2040
8,700
(1.6-fold increase)

China & India

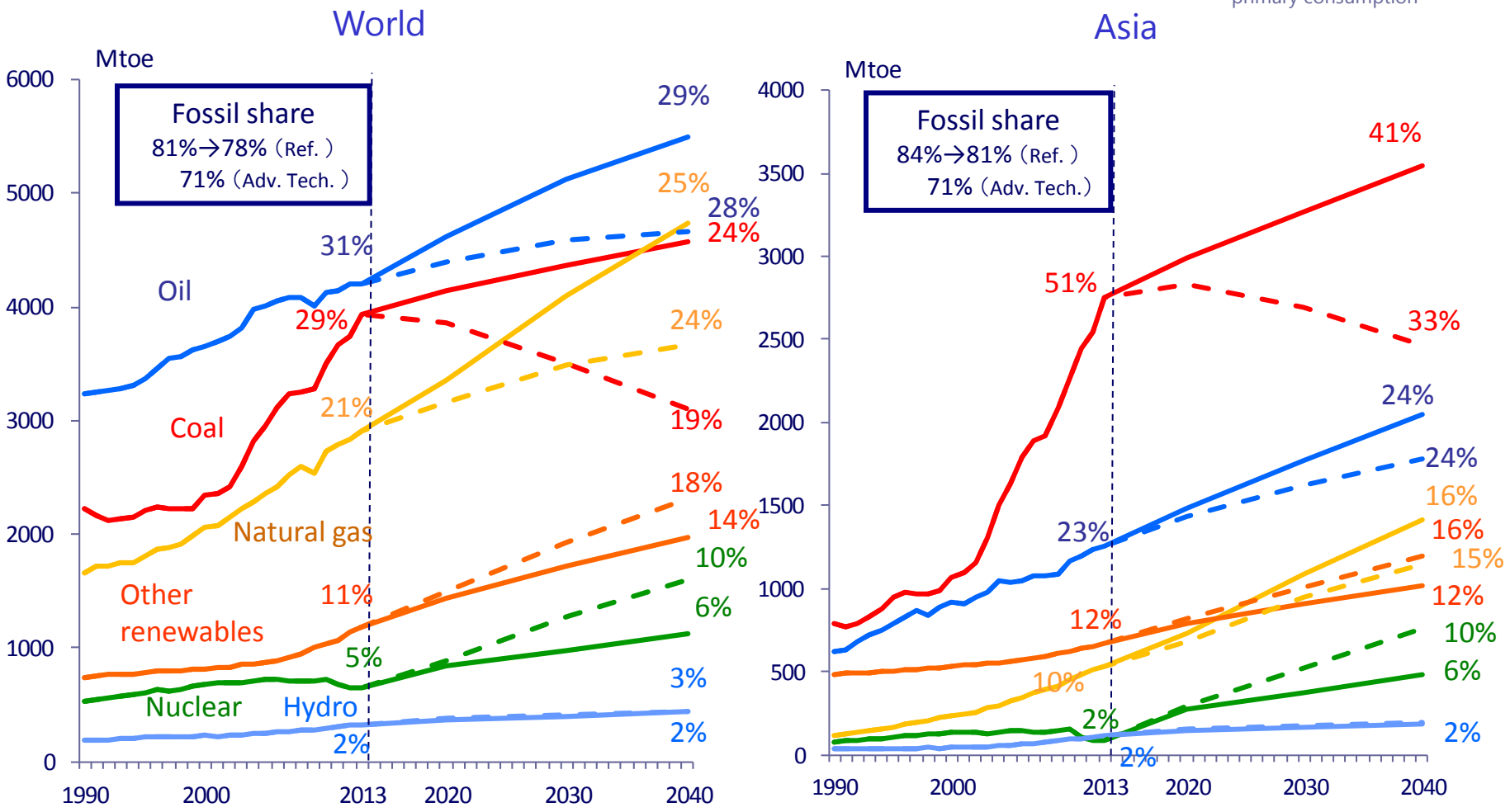
2013
3,000 780
↓
2040
4,200 1,800
(1.4-fold inc.) (2.3-fold inc.)

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

2. Primary Energy Consumption in the World
(3) Primary Energy Consumption by Source (Reference vs Tech. Ad.)

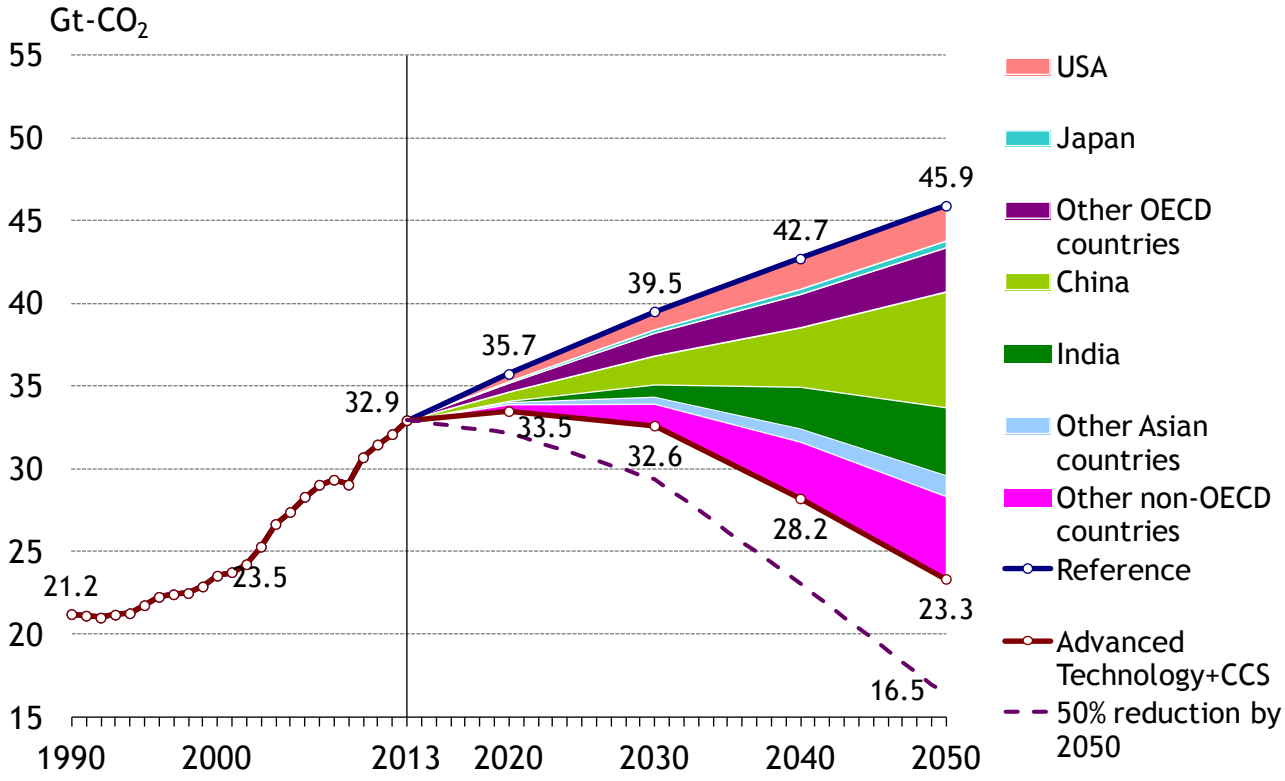
Solid lines: Reference
Dashed lines: Adv. Tech.

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



(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

2. Primary Energy Consumption in the World
(4) CO_2 Emission Reduction (Reference vs [Tech. Ad.+CCS])



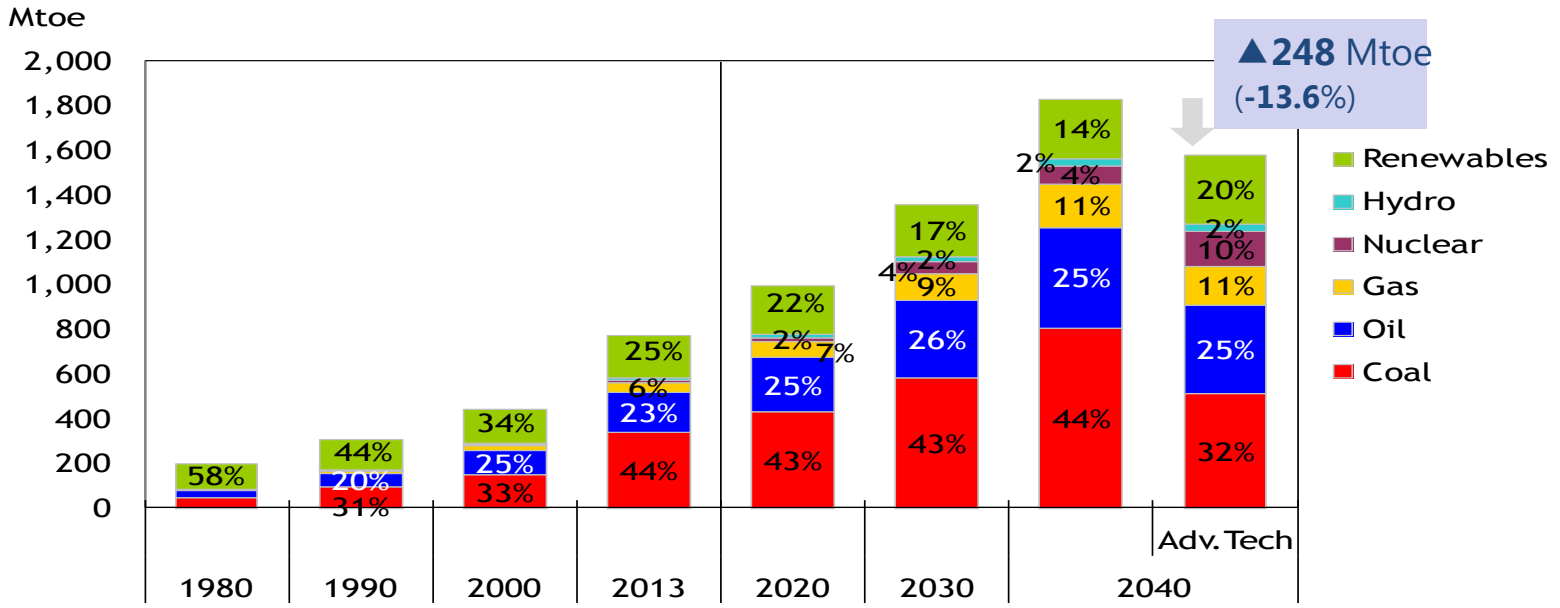
CO_2 Reduction in 2050

	Gt-CO_2	Share
USA	2.1	10%
Japan	0.7	3%
Other OECD	2.7	12%
China	6.8	30%
India	3.7	17%
Other Asian countries	1.3	6%
Other non-OECD	5.2	23%
OECD	5.5	25%
Non-OECD	17.0	75%
Non-OECD Asia	11.8	53%
World total	22.6	100%

- Asia has a huge CO_2 reduction potential; CO_2 emission reduction reaches 11.8 Gt in Non-OECD Asia and 6.8 Gt in China.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

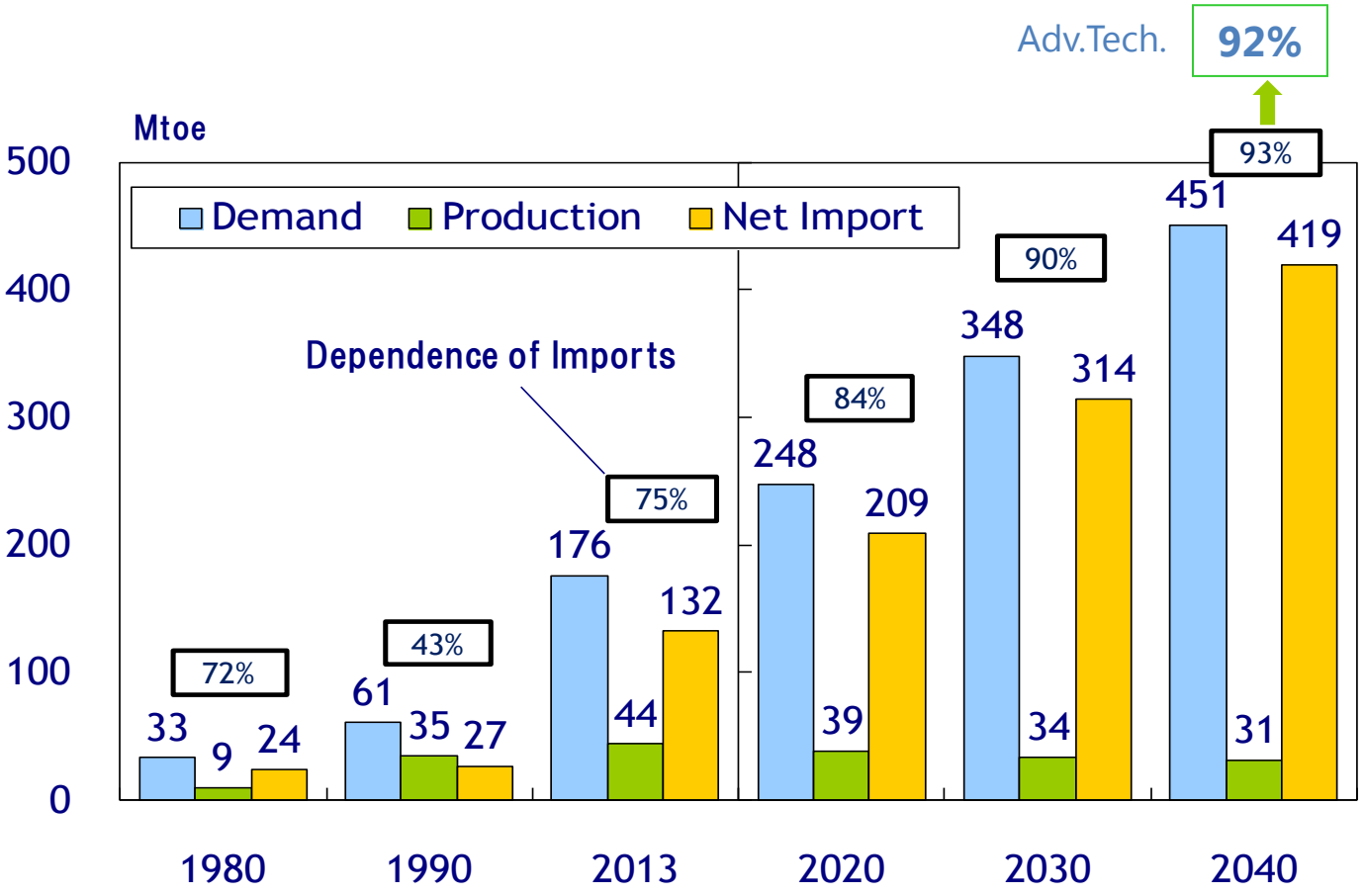
3. Primary Energy Consumption in India
(1) Reference vs Tech. Ad.



- In the Reference Scenario, TPED increases at an annual rate of 3.2%. Fossil fuels account for 81% of the increases by 2040.
- Driven by the power generation and industry sectors, coal maintains the largest share at about 44% throughout the projection period. Coal increases to 464 Mtoe. This increases is equivalent to the TPED of Japan.
- The power and industry sectors also lead natural gas consumption growth. Although development of domestic resources is expected, much of the natural gas consumption should be met by imports.
- TPED in 2040 in the Advanced Technologies Scenario is 248 Mtoe, or 13.6% lower compared with the Reference Scenario.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

3. Primary Energy Consumption in India
(2) Demand and Supply of Oil in India: Self-sufficiency Ratio



Net Oil Import

2013
2.7MB/D
↓
2040
Reference
8.7MB/D
(**3.2**folds)

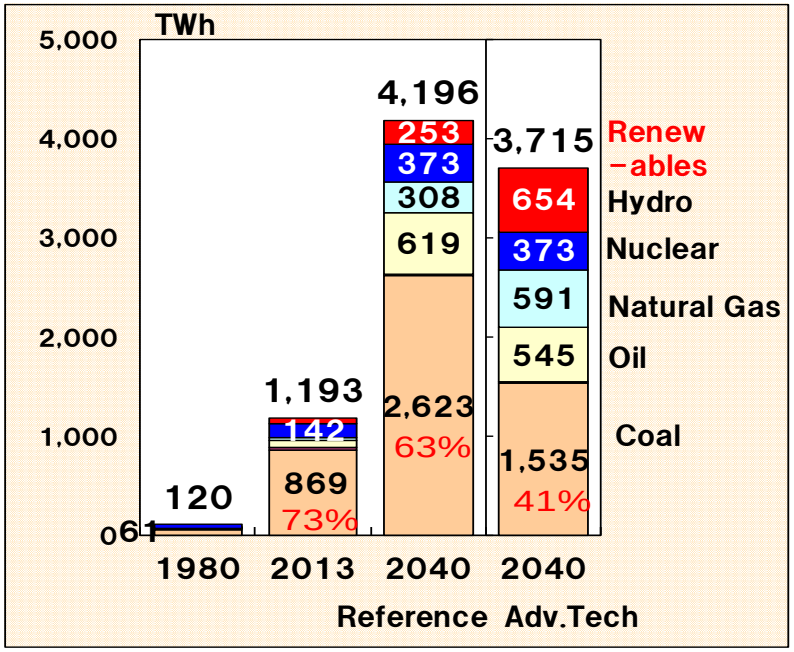
Adv. Tech. Adv.
7.5MB/D
(**2.7**folds)

- Net oil import is projected to expand from 132 million ton (2.7mb/d) in 2013 to 419 million ton (8.7 Mb/d) in 2040. Net oil import ratio reaches 93% in 2040.
- In the Advanced Technologies Scenario, net oil import ratio reaches 92% by 2040.

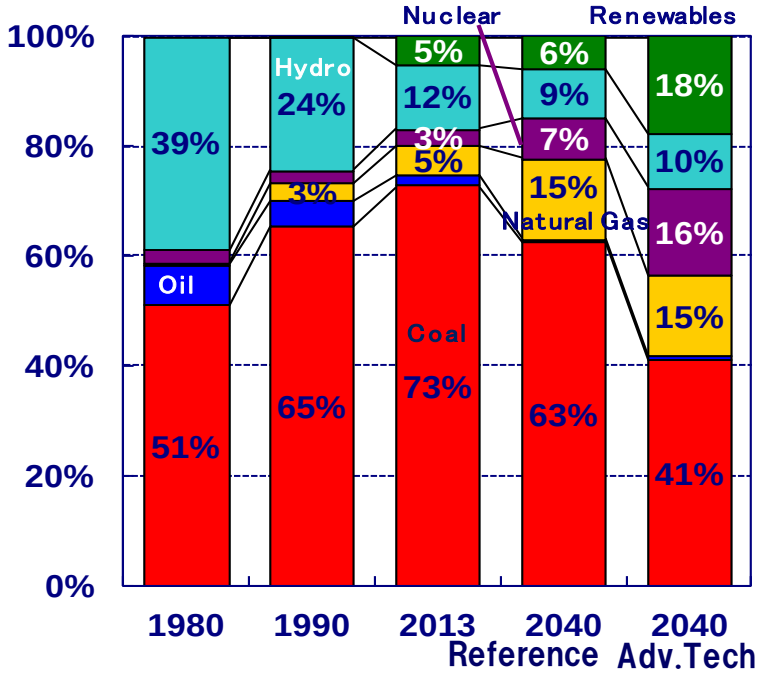
(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

3. Primary Energy Consumption in India
(3) Power Generation Mix in India (Reference vs Tech Ad.)

Power Generation



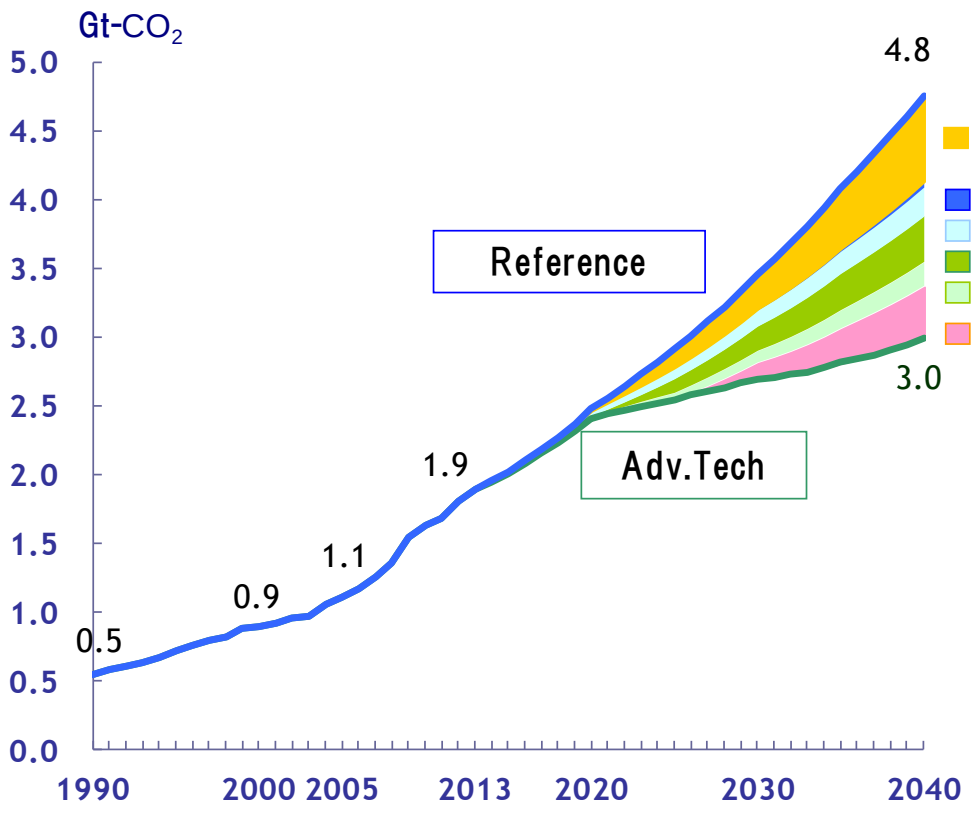
Power Generation Mix

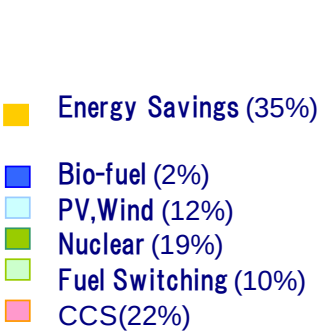


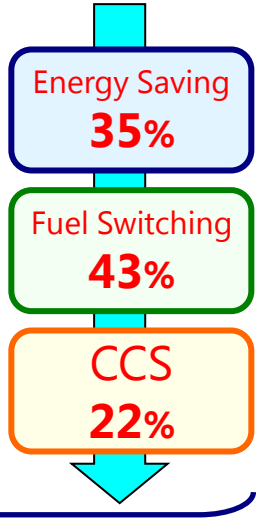
- Coal-fired power continues to account for the largest share. The generation efficiency improves led by the government's Ultra Mega Power Project to introduce several 4GW-class super critical coal-fired power plants.
- On the other hand, the share of natural gas and nuclear gradually expands and power generation mix becomes more diversified.
- Nuclear capacity increases from 5.8 GW in 2015 to 47GW in 2040 (a 8.1-fold increase) in reference scenario, 90GW in 2040(a 15.6-fold increase) in Advanced Technologies Scenario.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

3. Primary Energy Consumption in India
(4) CO_2 Emission Reduction in India (Reference vs Tech Ad.)







2040
- 1.8 Gt-CO2
(- 37%)

	Gt-CO_2	Share
Energy Saving	0.6	35%
Bio-fuel	0.0	2%
PV,Wind,etc	0.2	12%
Nuclear	0.3	19%
Fuel Swithching	0.2	10%
CCS	0.4	22%
Total	1.8	100%

- In the Reference Scenario, CO_2 emissions increase by 2.9 Gt (a 2.5 fold-increase) in 2040 from 2013.
- In the Advanced Technologies Scenario, CO_2 emissions are 1.8 (37%)lower from the Reference Scenario.

(Source) IEEJ, Asia/World Energy Outlook 2015, Oct. 2015

Clean Coal Technology

Development of High-Efficiency Coal-Fired Thermal Power Plants

●Advanced Ultra-Super-Critical (A-USC) Pressure Thermal Power Generation
Elemental technology is currently being developed.

●Integrated Coal-Gasification Combined Cycle (IGCC) Power Generation

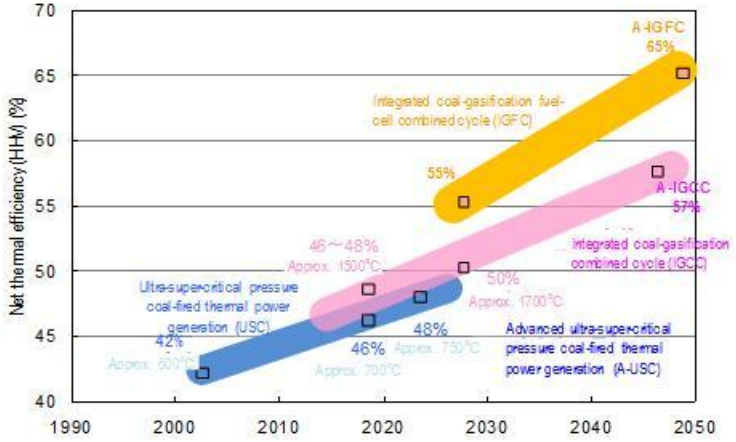
Air-blown IGCC (250 MW, Nakoso)
March 2013: Demonstration test completed.
April 2013: Ownership transferred to Joban Joint Power.
June 2013: Commercial operation started.
(Clean Coal Power R&D Company → Joban Joint Power Co., Ltd.)

Oxygen-blown IGCC (166 MW, Osaki)
Osaki CoolGen Project (2012 to 2021)
Demonstration test to be started in 2017.
(J-POWER, Chugoku Electric Power Co., Inc.)

●Integrated Coal-Gasification Fuel-Cell Combined Cycle (IGFC)

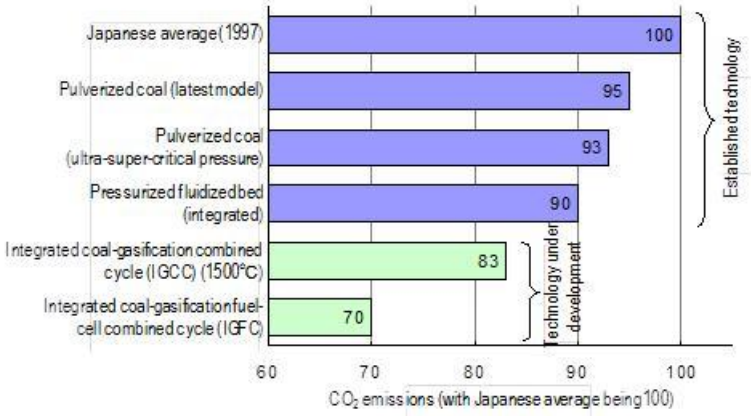
IGCC in Nakoso

Improvement of thermal efficiency of coal-fired thermal power generation



Source: Cool Earth 50 Energy Innovative Project Plan

CO2 Emission Reduction



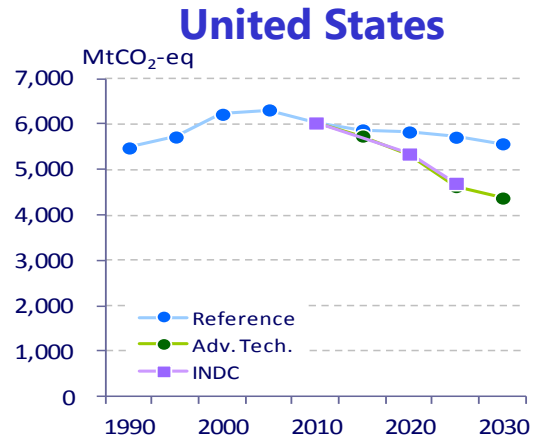
Source: CCUJ, "Coal Science Handbook 2005"

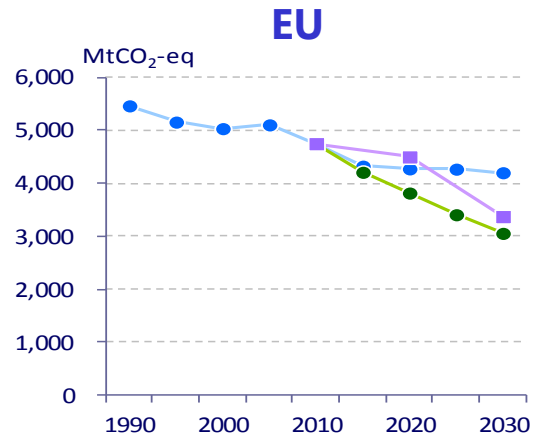
Intended Nationally Determined Contributions (INDCs) of major countries

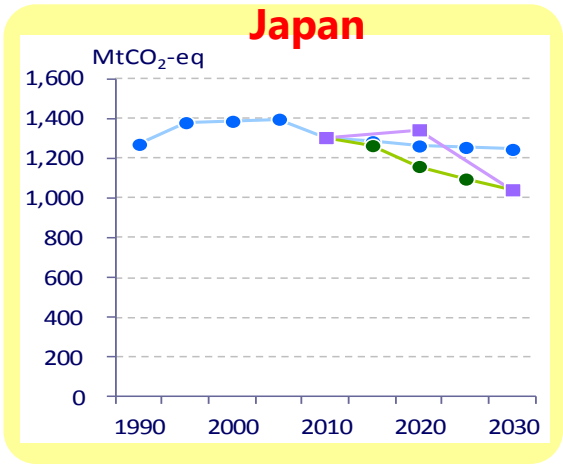
Party	Date of submission	Target type	Reduction target	Base year	Target year	Coverage
EU	Mar 6	Absolute emissions	40%	1990	2030	GHG
United States	Mar 31	Absolute emissions	26～28%	2005	2025	GHG including LULUCF
Russia	Apr 1	Absolute emissions	25～30%	1990	2030	GHG
China	Jun 30	GDP intensity	60～65%	2005	2030	CO_2
Japan	Jul 17	**Absolute emissions**	**26%**	**2013**	**2030**	**GHG**
Indonesia	Sep 24	Reduction from BAU	29%	BAU	2030	GHG
Brazil	Sep 30	Absolute emissions	37% (43% for 2030)	2005	2025	GHG
India	Oct 1	**GDP intensity**	**33～35%**	**2005**	**2030**	**GHG**

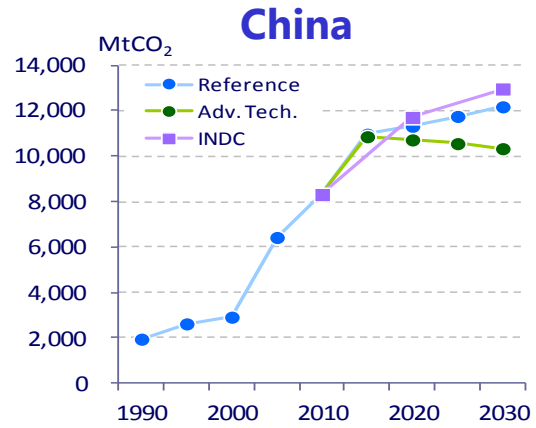
- In advance of the United Nations Climate Change Conference (COP21) in Nov. 2015, the participating countries have submitted the Intended Nationally Determined Contributions (INDCs) which present the post-2020 climate actions each country intends to take.
- By Jan 5th, 160 countries and regions (totaling 187 countries) have submitted their INDCs.
- The 8 major countries and regions shown above cover 65% of global GHG emissions in 2010.

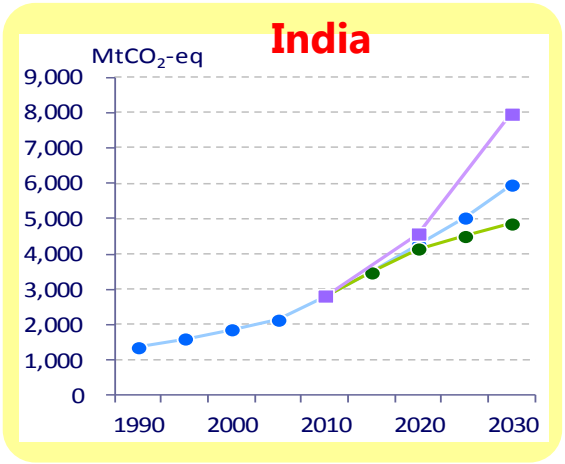
Comparison of INDCs with the Reference/Adv. Tech. Scenarios by country

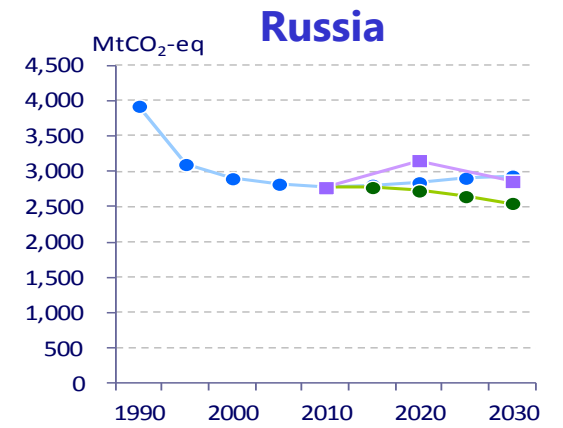












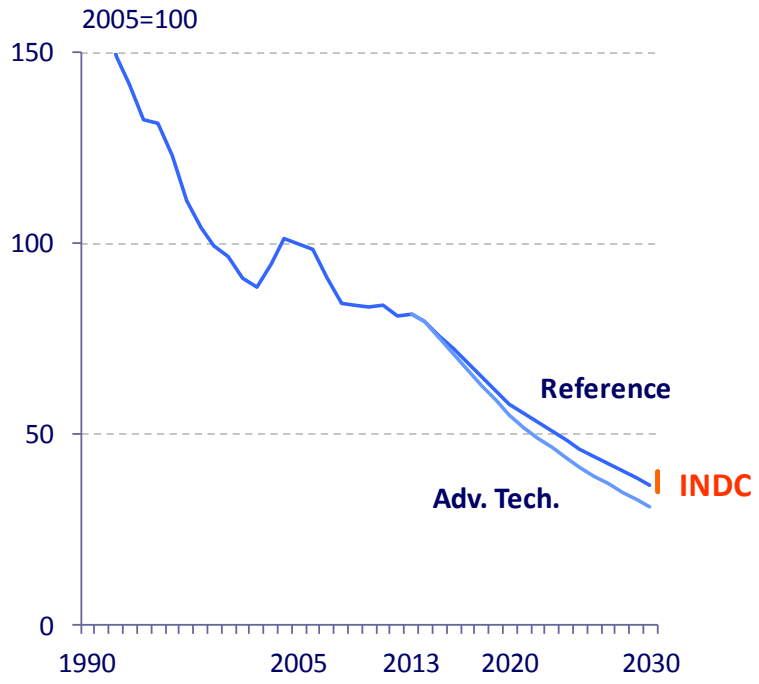
- The INDC targets of the United States and Japan are as ambitious as the
- Advanced Technologies Scenario. The target of EU is also positioned near the ATS.
- The targets of China and India exceed the Reference Scenario in terms of CO_2/GHG emissions.

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

Comparison of CO_2/GHG intensities (China and India)

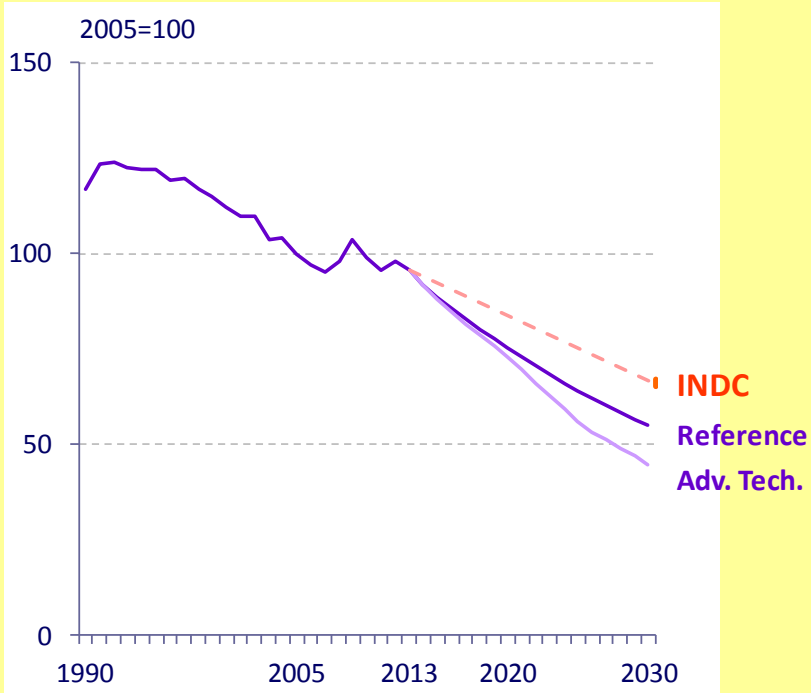
China

INDC: 60 to 65% reduction from 2005



India

INDC: 33 to 35% reduction from 2005

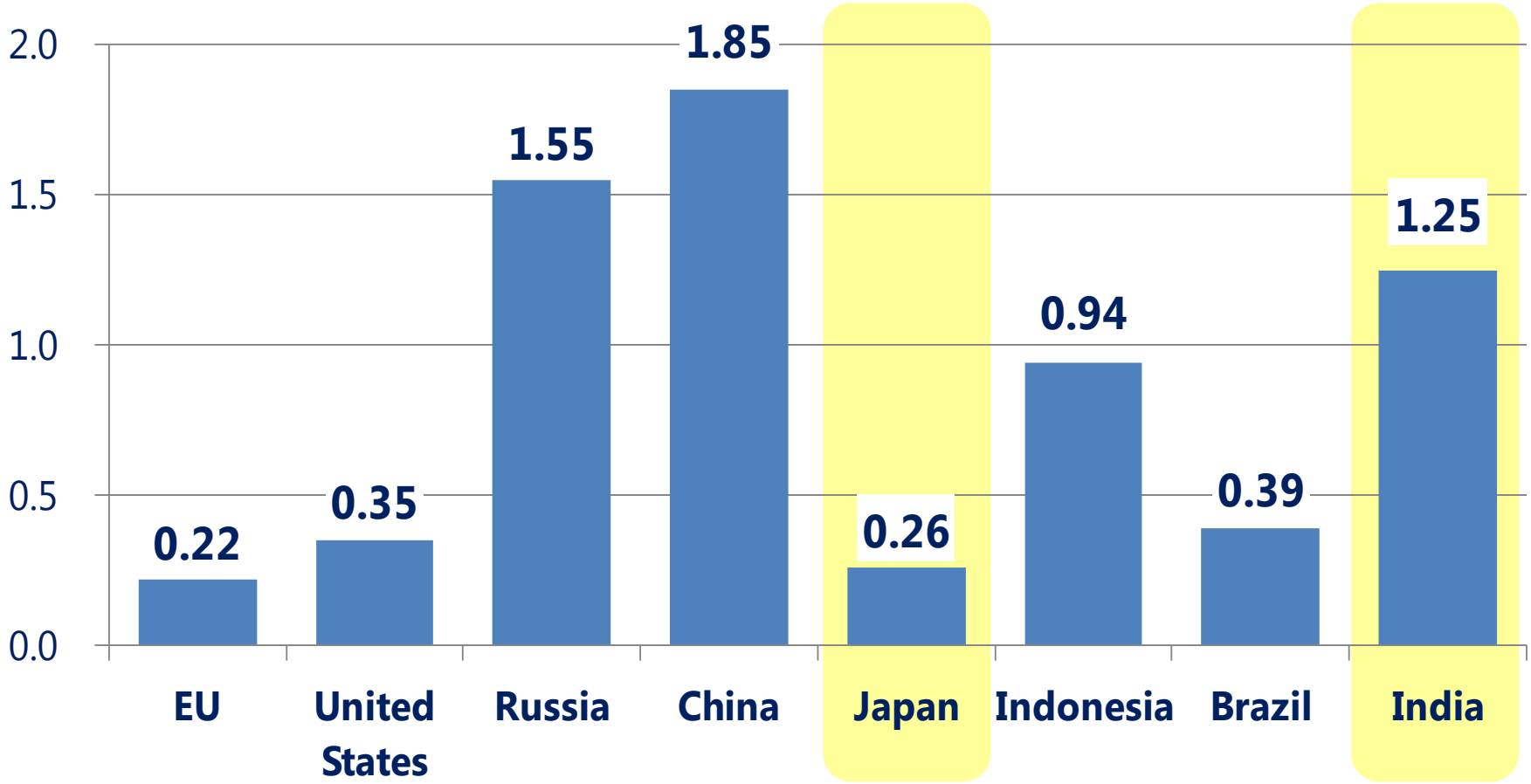


Assumed the reduction rate of CO_2 intensity as identical to that of GHG intensity.

- In most countries including emerging nations, the GHG intensity (i.e. GHG emission divided by real GDP) has rapidly been declining, even though total GHG emission has been increasing.
- The continuation of the historical trends (the Reference Scenario) shows that the targets are hardly challenging.

Comparison of CO2 emissions per GDP as of 2013

CO2 / GDP (kgCO2 per 2005 US dollar)



(Source) Source: IEA "Energy Balances of OECD, Non-OECD countries 2015"

Conclusion

1. **Energy Mix in Japan** (Tech Ad. Scenario) was determined by considering " **3E+S**"

2. **Possibly Best Energy Mix** of the world can also be determined in a similar manner

3. **India may not be an exception**.

（Note） **The best energy mix** for India can be **scrutinized** through **power generation cost analysis**

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