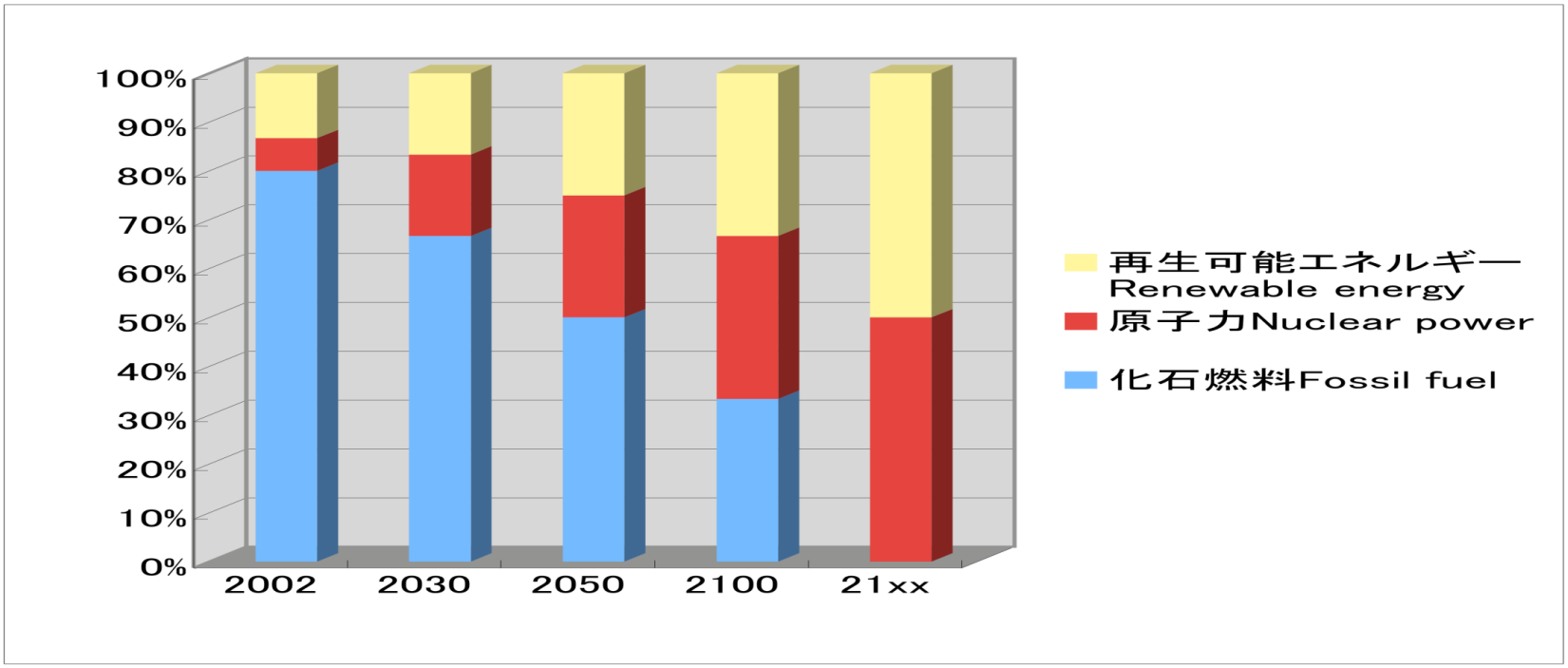
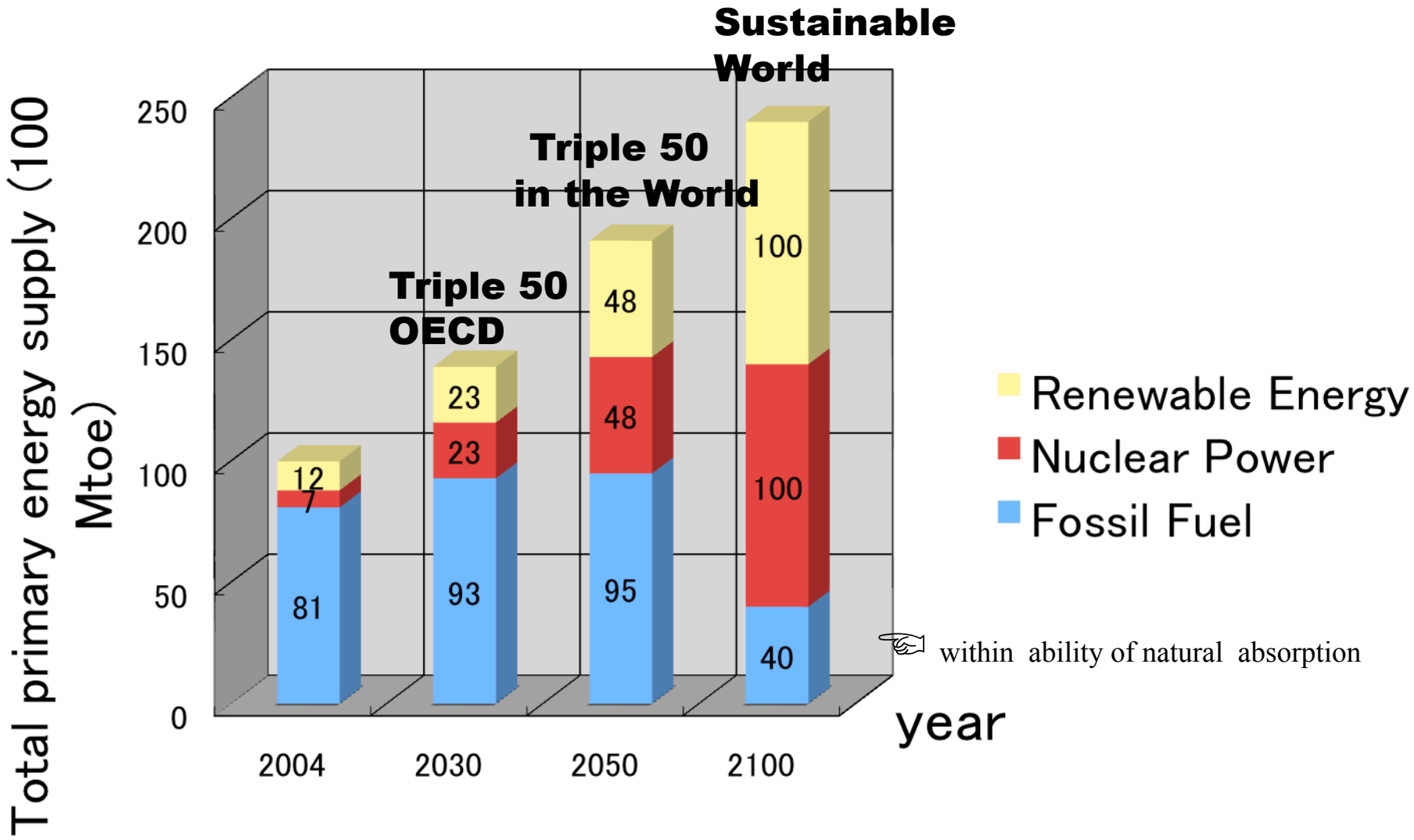
The University of Tokyo IR3S Energy Sustainability Forum International Symposium “Pathway to Low Carbon Society after Kyoto Protocol”October 28th (Wed.), 2009 13:00 - 17:30U Thant Hall, United Nations University (5-53-70 Jingumae, Shibuya-ku, Tokyo)

“Midterm CO_2 Reduction Target in terms of Science, Fairness and Feasibility”



Dr. Tetsuo Yuhara
Project Prof. IR3S, The University of Tokyo
Research Director, Canon Institute for Global Studies

Susutainable energy mix in this century(<550ppm)

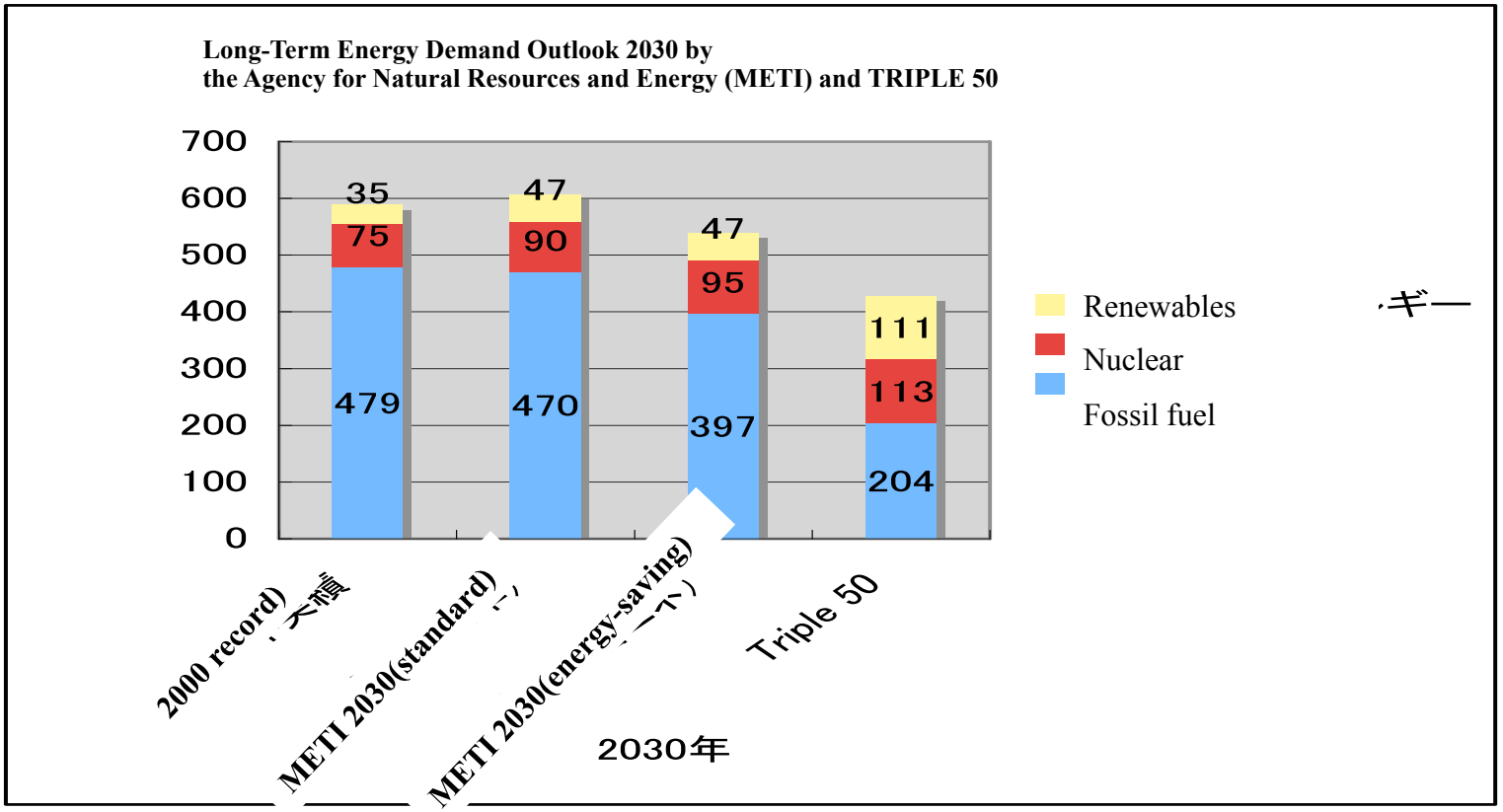


Triple50: Self-sufficiency 50%, Dependency on Fossil fuel 50%,Energy efficiency 50%

Sustainable = Emission of CO_2 within Earth ability of natural absorption (exhausted with fossil fuel 4Btoe)

“Triple 50 “ for Japan, proposed by the Univ. of Tokyo

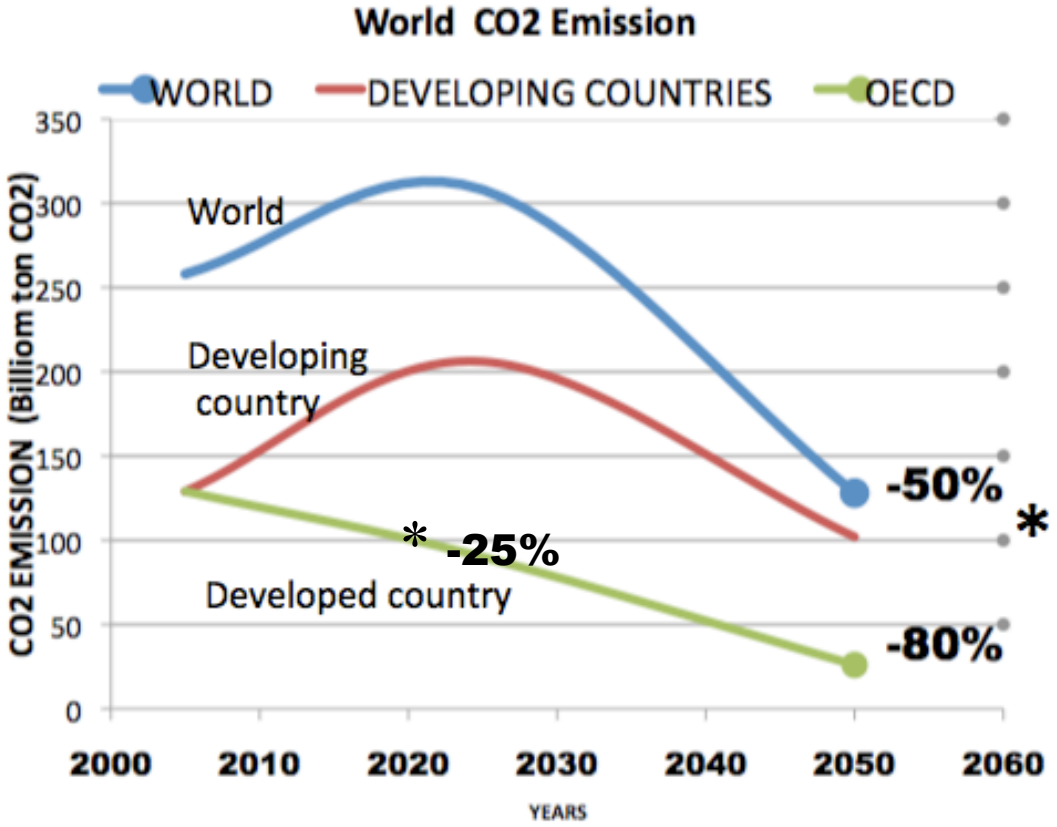
	Energy self-sufficiency	Dependency on oil	Energy Utilization Efficiency
now	20%	80%	35%
2030	50%	50%	50%



Triple50 Conference of Sustainable Society（UT＋TOSHIBA・HITACHI・MHI・IHI） Research Collaboration, May 2005
http://rmo.iis.u-tokyo.ac.jp/jizoku.index.html

Setting the target
Concept and approach(Example)

CO2 Emission reduction -50%(World) -80%(OECD) in 2050
Global warming within 2℃ in this century

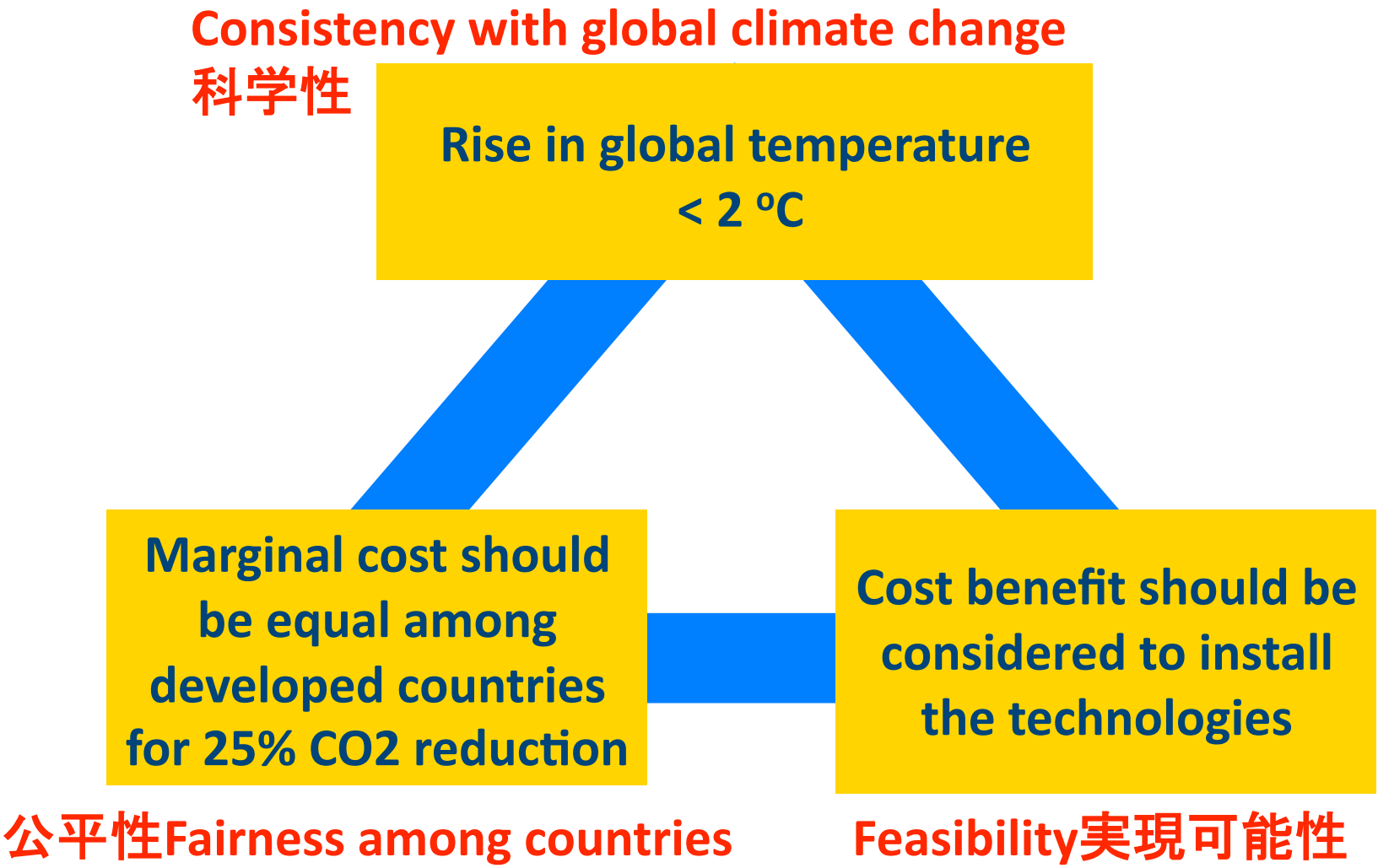


Issues on CO_2 emission reduction

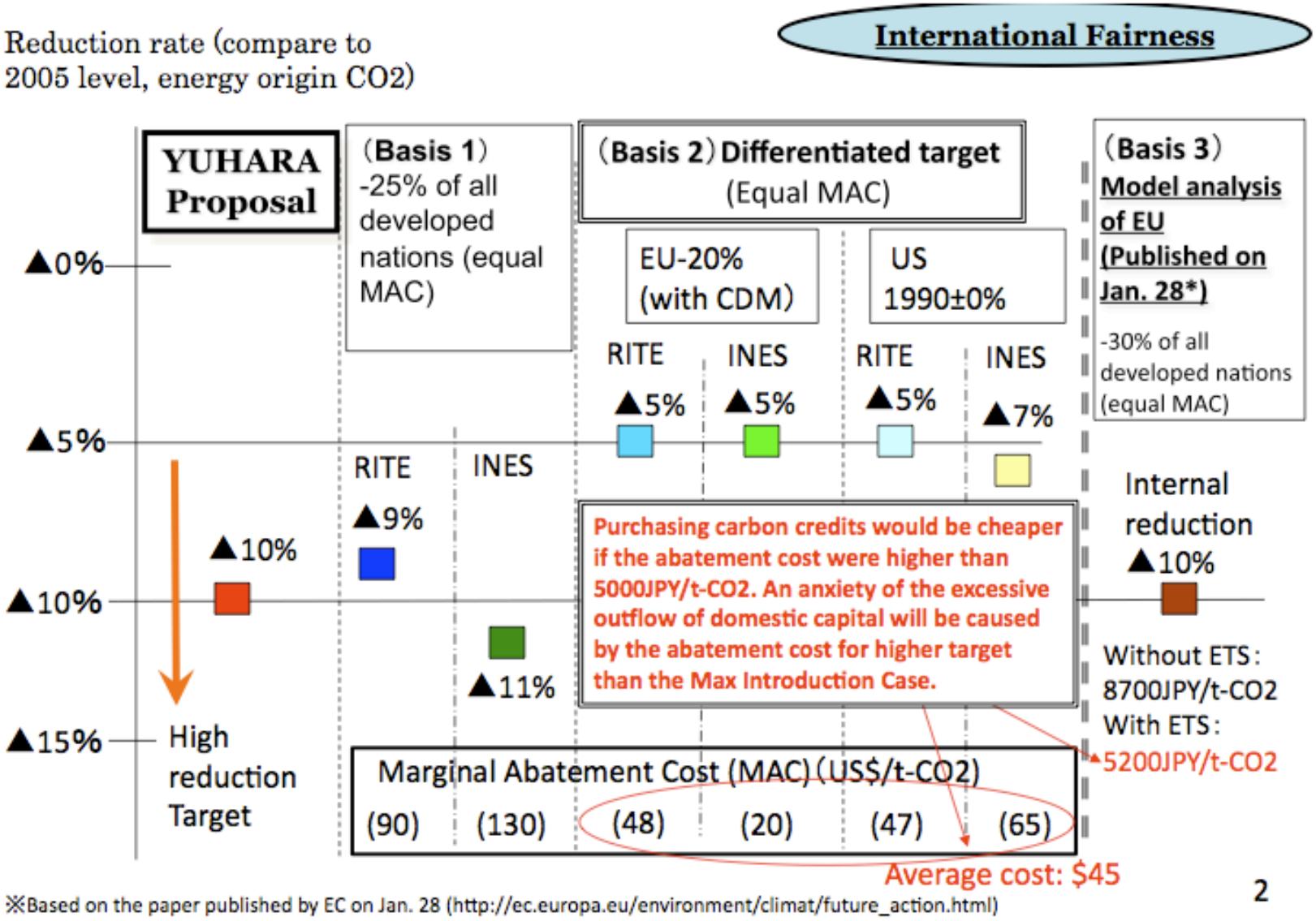
- **Scientific and Long-term Scenario of GHG reduction**
  --- CO_2 curve that should be globally shared
- **Differentiated role and contribution of each country**
  ––– Promises by developed countries and
  emission reduction curve for developing countries
- **To share the gap**
  ––– Ideal energy mix and hard truth
- **Measures to overcome the gap**
  ––– Technology development and its diffusion/transfer
  Sharing the key technologies and those deployment
- **To build a future international cooperative system**
  ––– Advanced CDM and ETS

2009.4 T.YUHARA (proposed to “Committee on mid-term target”)

Setting & meeting Target for GHG Emission Reduction by 2020

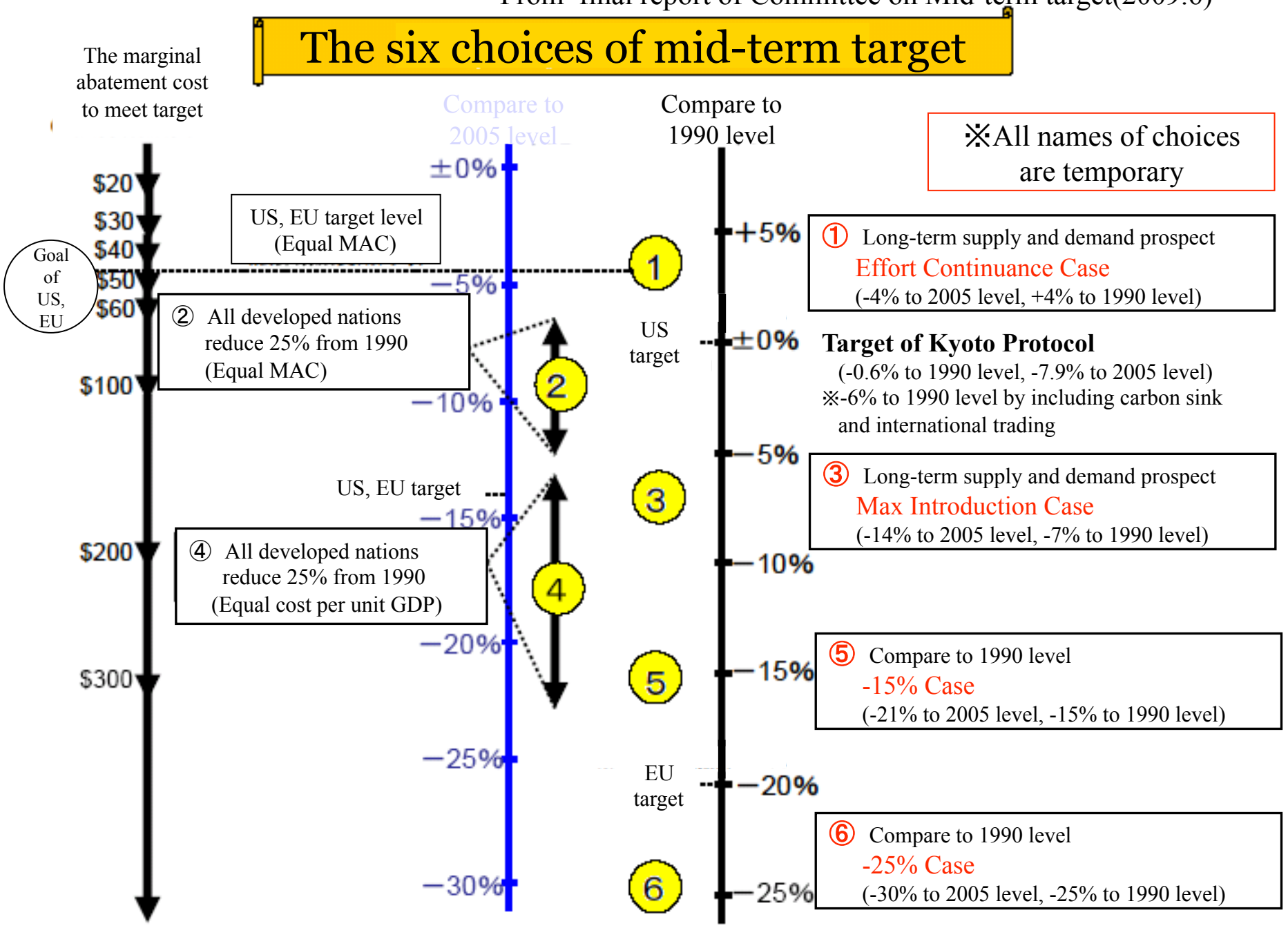


Japanese Mid-term (2020) Target and Abatement Cost



From final report of Committee on Mid-term target(2009.6)

The six choices of mid-term target

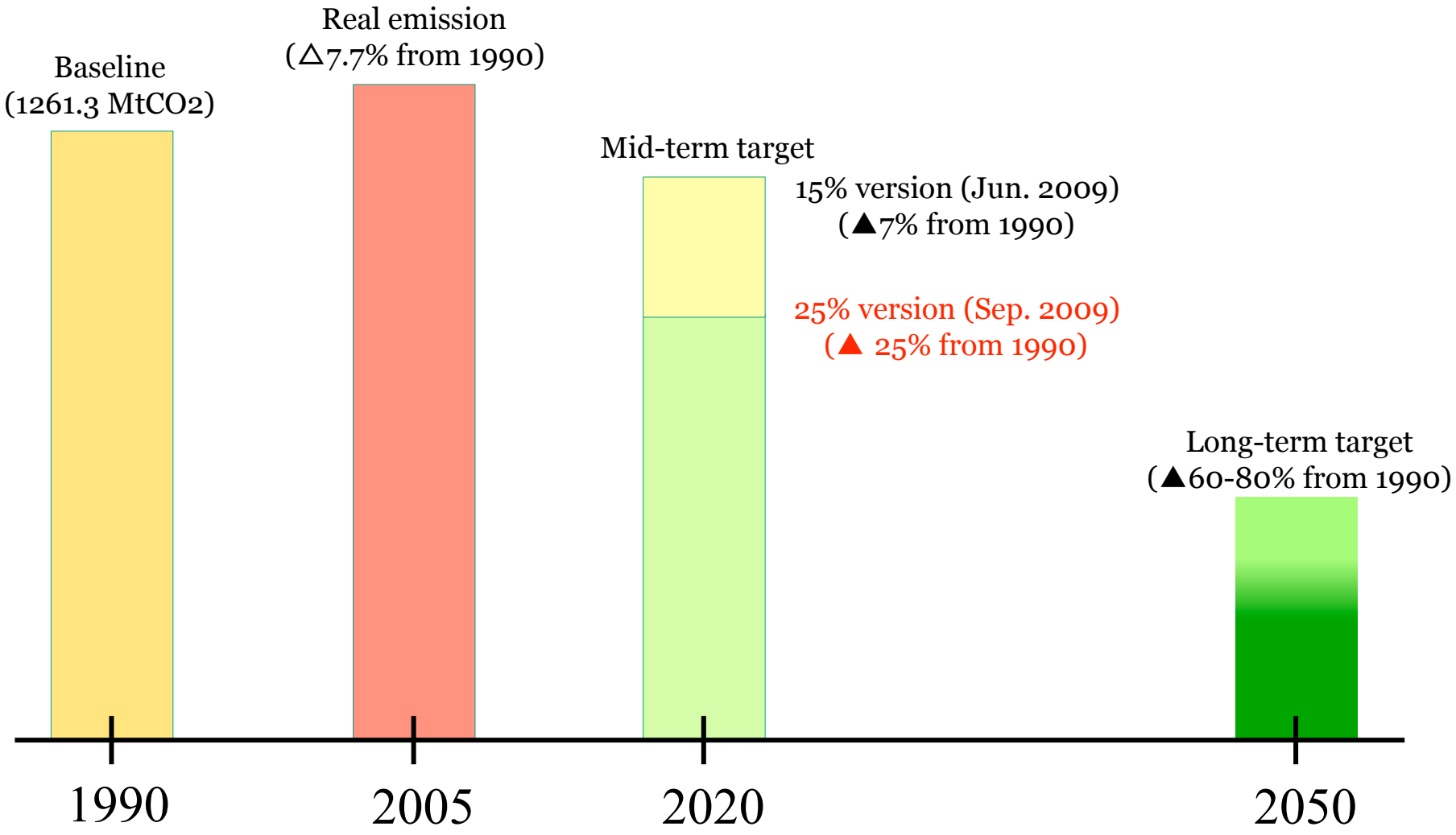


CO_2 Emission Reduction and its Cost Impact

- METI proposed 47 kinds of technologies and policies to reduce CO_2 emission in the long-term supply and demand forecast.
- 27 measures will result in positive impact on economy
- The following 5 measures will cost over 5,000 JPY/CO_2-ton
  - BEMS (Building and Energy Management System)
  - Energy Efficient Resident
  - Heat Pump, co-generation, Fuel Cell for buildings and houses
  - Solar Power
  - Next generation vehicles (Hybrid, Electric, Plug-in Hybrid, Fuel-Cell)

** These measures help job creation.

Mid-term GHG reduction Target of Japan



Necessary key measures and policies

measures

policies

	Power generation Photovoltaic Nuclear power	Transportation Next generation Automobile	Housing Thermal isolation structure
Previous Target (Jun. 2009) (▲7% from 1990)	PV: 20 times to current NP operation rate: 80%	New sales: 50% Holdings: 20%	New house: 80%
	•Fixed purchase price system •Subsidy to house PV	•Subsidy for purchasing eco-car	•Strengthen the standard of energy conservation house •Subside for purchasing green electronics
Current Target (Sep. 2009) (▲25% from 1990)	PV: 55 times to current NP operation rate: 90%	New sales: 90% Holdings: 40%	New house: 100% Reform: 100%
	•Obligating to set PV facility for new house and large-scale old house	•Sales prohibition and car inspection exclusion to old model automobile	•Enforce preferential tax and subsidy system •Obligating energy conservation standard

Production reduction of energy intensive industries (iron and steel, chemical industry, cement , etc.)

Necessity of carbon price policies (emission trading system, carbon tax)

Source: “Long term outlook for energy demand and supply”, METI, Aug. 2009

Economical Impacts(Results by “Committee on Midterm target”

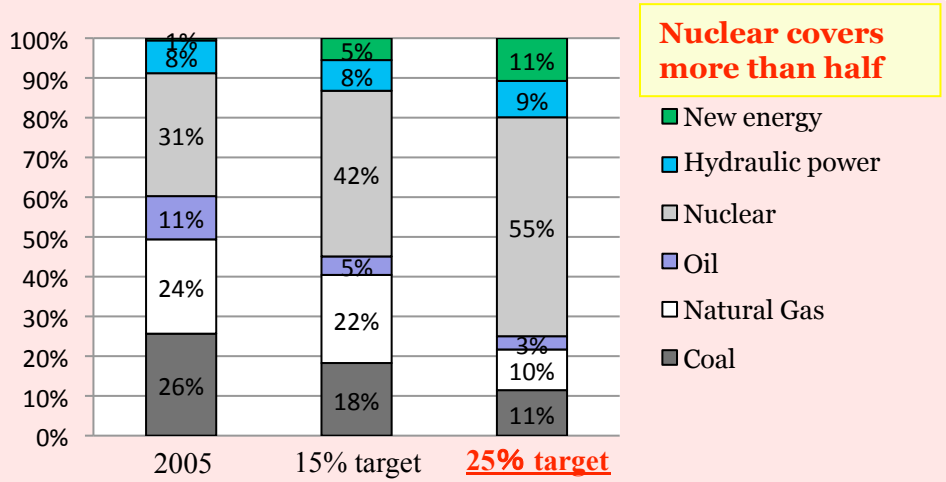
※1) The change rates show the differences compared to the baseline in 2020.
※2) The results are analyzed using the CGE model of Japan Center for Economic Research

	Baseline (△4% from 1990)	Previous Target (▲7% from 1990)	Current Target (▲25% from 1990)
Real GDP	Based on an assumption of a 1.3% annual growth of Real GDP	▲0.6% in 2020 (depressing)	▲3.2% in 2020 (depressing)
Unemployment rate		△0.2% (rise)	△1.3% (rise)
Private plant investment		△0.1%	▲ 0.4%
Disposable income		▲40,000JP\/yr Per household	▲220,000JP\ /yr Per household
Utility costs		△30,000JP\ /yr Per household	△140,000JP\ yr Per household
Marginal abatement cost	35-62 US$/tCO2 Cannot be compared simply due to the different models	15,000YP\/tCO2 If putting the cost into energy price, it would make a rise by 30JP\/l for gasoline	82,000YP\/tCO2 If putting the cost into energy price, it would make a rise by 170JP\/l for gasoline

Source: “Long term outlook for energy demand and supply”, METI, Aug. 2009

Methods to meet the 25% reduction target

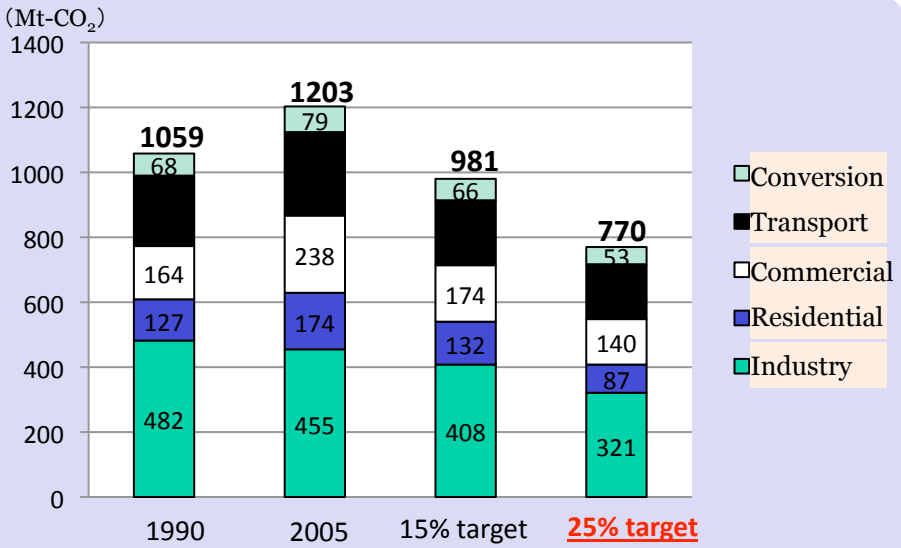
Power supply composition



Nuclear covers more than half

- New energy
- Hydraulic power
- Nuclear
- Oil
- Natural Gas
- Coal

Sectoral CO_2 emissions



Necessary sectoral reduction rates from 2005 to meet the -25% target

Industry:	-29%	Commercial:	-41%
Transport:	-34%	Conversion:	-33%

Residential emission needs to be Halved.

※According to the analysis of the Mid-term Target Examination Committee and the Institute of Energy Economics Japan (IEEJ)

Necessary measures

○Photovoltaic generation

Introducing to all new house

Introducing to 600,000 old house annually
(equal to the house number in Nagasaki Prefecture)

○Energy-conservation house

The severest standard (1 MJPY) for all new house

Reforming all old house to energy-conservation type (2 MJPY)

○High efficiency boiler

Introducing to all households with more then two persons and parts of single households

○Next generation automobile

Sales prohibition for gasoline automobile

○Restriction of economic activities

Production reduction of steel by 18%, cement by 25%, etc.

Case of 25% CO_2 Emission Reduction ⑥ from the Midterm Target Committee (Cabinet Secretariat)

25% reduction from the level of 1990 (30% reduction from 2005)

Phenomenon:

- ✓ all appliances/equipments are state-of the art.
- ✓ Economic activities are cutdown

Principles:

- ✓ Mandatory to replace all appliances/ equipments to be state-of-the-art.
- ✓ Mandatory for carbon pricing

Technology installation and Policies:

- ✓ Solar Power :
  - 55 times of current capacity of solar power
  - Newly built and some of existing houses are obliged to install solar power devices.
- ✓ Next Generation Vehicles :
  - 90% of sales of new car and 40% of existing cars should be the next generation v-ehicles.
  - Prohibition of sales and inspection-and-maintenance of conventional vehicles
- ✓ Heat insulating houses:
  - 100% of newly-built house and existing house install heat insulating.
  - Mandatory of energy-conservation standards for all houses
- ✓ Energy Intensive Industries :
  - Production cutdown
  - Mandatory of ETS and Carbon tax

Comparisons ;Outlooks of Energy supply through 2030 to 2050 in Japan

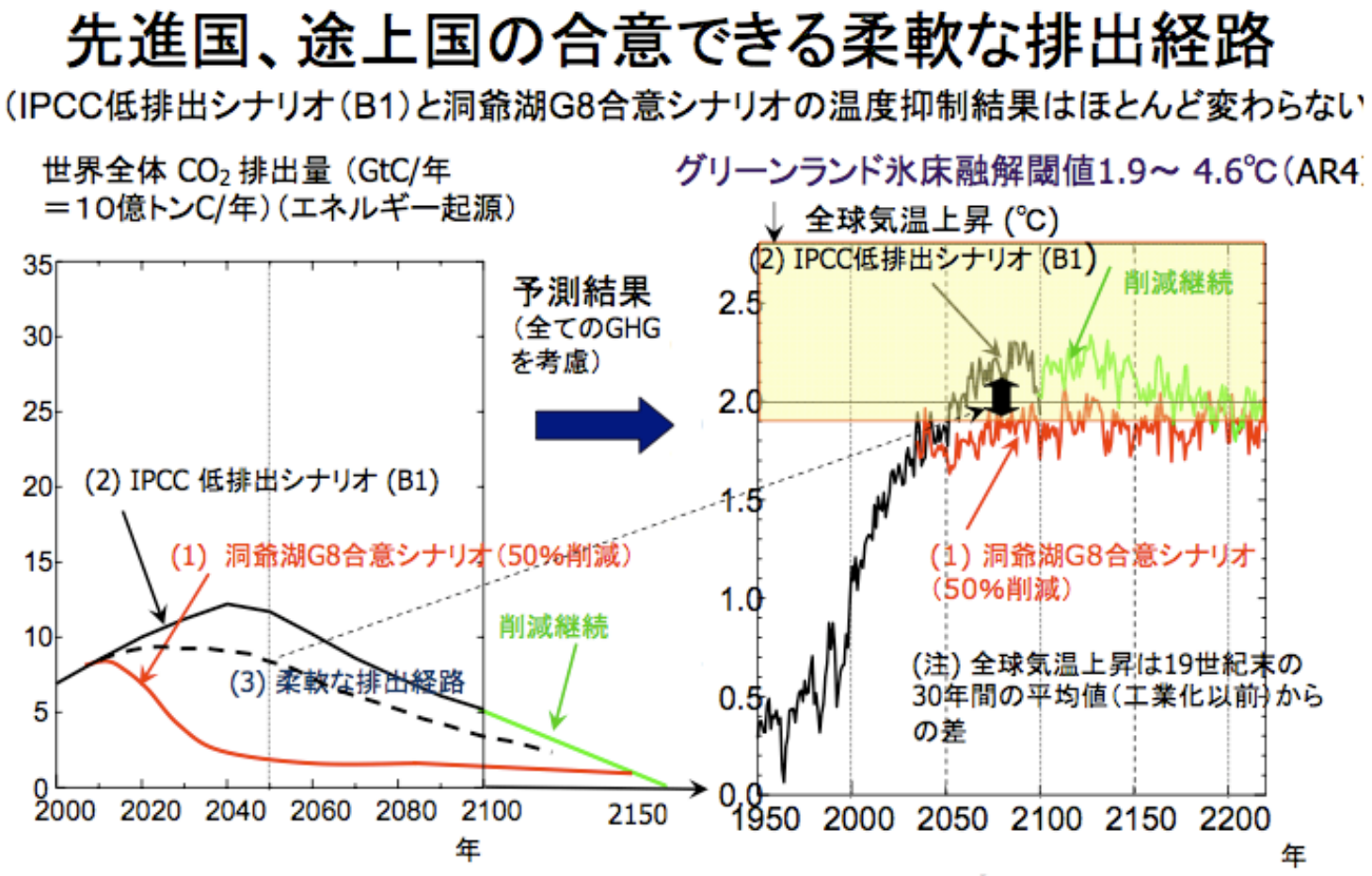
Year	2005	2020			2030		2050
	Real Value	METI 2009.8	WEO 2009	NIES	METI 2009.8	WEO 2009	IEE Japan
TPES(Mtoe)	544	511	465	477	476	446	364
CO2 Reduction (2005)	-	-16	-21	-32	-27	-48	-65
% (1990)	+8	-6	-10	-23	-18	-40	-60
Fossil Fuels %	82	73	71	68	68	57	48
Nuclear %	12	18	23	19	21	31	31
Renewable Energy %	6	9	6	13	12	11	21

Outlook of mixtures of energy supply through 2030 to 2050 in Japan

Year	2005	2020		2030
	Real Value	METI 2009.8	Current Target	Triple 50
TPES(Mtoe)	544	511	511	480
CO2 Reduction (2005)	-	-15	-30	-40
% (1990)	+8	-6	-25	
Fossil Fuels %	82	73	67	50
Nuclear %	12	18	22*	25
Renewable Energy %	6	9	11	25

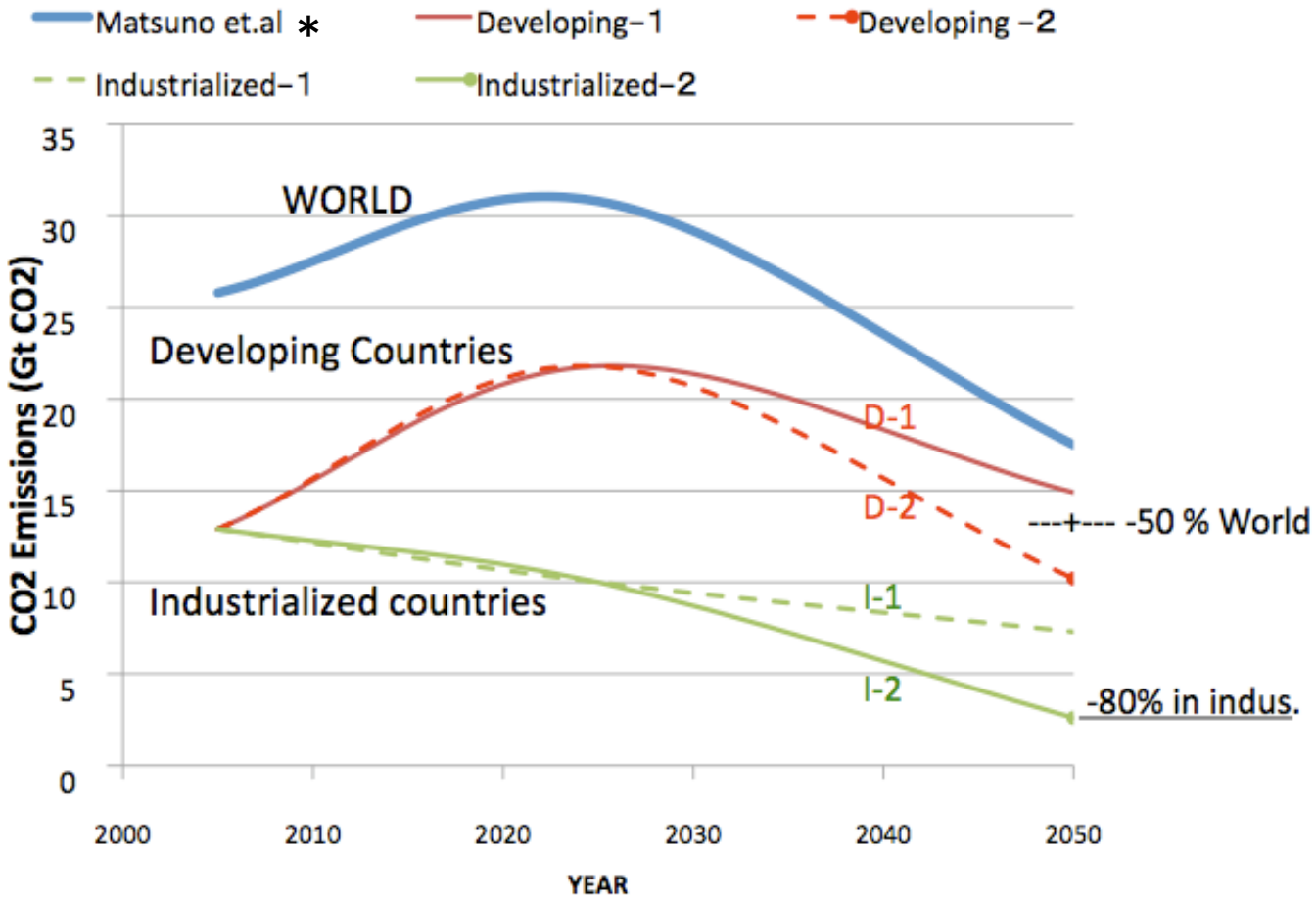
* Nuclear power plants 12-15 (operation ratio in all plants: 80-90%)

Flexible pathway of emission reduction , agreed among developed and developing countries



(出典:電中研2007) GHG(エアロゾルの寒冷化を含む)全てを考慮した気候モデル(大気海洋結合モデル、CCSM3)を用いて電中研スパコンで予測した結果

World Reduction Curve of CO_2 emissions (Peak&decay curves , cumulative emission 640Gt and within 2℃ in this century) and differentiated roles of developed and developing countries



Agreement in Tohyako Summit -50% in the world = (I-2 +D-2) ,
Recommendation by Prof. Matsuno et.al. -32% = (I-2 +D-1) ,or (I-1+ D-2)

＊ T. Matsuno, K.Maruyama, J.Tsutsui (2009)

Innovative technologies for proposed sustainable energy vision

1. High efficient, power generations of gas and coal

⑴Combined cycles of natural gas with-SOFC and gas turbine η >65%)
⑵Clean coal technology "IGCC "IGFC ” Zero emission plant η>55%)

2. Nuclear energy and spent-fuel recycle systems

⑴ Fast Breeder Reactor system with sustainable fuels)
⑵High Temperature Gas Reactor

3. Renewable energy and stabilized with battery innovation

⑴Advanced battery systems- from hybrid vehicle to electric vehicle, toward fuel-cell vehicle (Lithium-ion battery, NaS battery, etc)
⑵Combination of battery to solar power and wind power system
⑶Geothermal cogeneration system (small and local)
⑷Advanced process and system for biomass energy and biomass fuels
⑸Ocean energy tide and current, offshore wind etc.)

4. Energy conservation systems in industrial sectors

⑴High quality recycle steels from scrap steels(super steel)
⑵Industrial complex of energy, supplying thermal and electricity to factories
⑶Co-generation and co-production plant systems

World energy mixture to 50% CO_2 reduction in 2050
-role of nuclear energy

year		2005	2030	2050	
㊀Population(billion)		6	8	10	
㊁GDP(Trillion US$)		36	67	100	
㊉Total Primary Energy Supply (TPES:100Mtoe)		103	140	187	
④Fossil Fuel(100Mtoe)		91	93	~~94~~	47
Energy Mixture (Fossil:Nuclear:Renew.E) %		88: 7: 5	67:17:17	~~50:25:25~~	25:38:38
⑤CO_2 Emission(100M CO_2 · t)		266	268	268	134 (-50%)
⑥CO_2/GDP（Ct／M$）		200	108	~~73~~	37
⑧Nuclear(100Mtoe) （Share of TPES）		7.2 (7%)	23.4 (17%)	47 (25%)	71 (38%)
Nuclear	⑨ Electric. (TWh)	2,768	9,000	~~18,000~~	27,000
	⑩Capacity (GW)	385	1200	~~2400~~	3600
⑪Uranium(1000tU/y)		67	230	450	675
Total Accum. (MtU)		---	4.4	11.2	18.0

＊Uranium Reserve 4.5MtU(Cost<$130/kg), Ultimate reserve 14.4MtU

Hard Truth to Fill in the Gaps

Uranium Reserve for Nuclear Power Plant

- Uranium is less expensive energy resource than fossil fuels, however, reserves are not enough to fill up the capacity of nuclear power generation in 2030 and 2050.
- Estimated Uranium reserve is 4,540 thousand tU (its cost is less than 130USD/kg). Ultimate reserve is 14,400 thousand tU. It is less amount to operate 1,200GW in 2030 and 3,600GW in 2050 of Nuclear Power Plants
- Fast Breeder Reactor cycle should be installed before 2050.

Availability of Renewable Energy Resource

- Used renewable energy resources are not enough in 2050. Unused renewable energy resources should be introduced.

Possibility of 30% CO2 Emission Reduction

		CO2 reduction (Mton)	Reduction % to 2005
Nuclear Power Plant	90% operating rate for 15 Newly-built plant	163	13.5
Thermal Power Plant	Gas Power Plant (MACC)	8	0.7
	Bio-mass mixed-combustion	50	4.2
METI's maximum introduction case	< 5,000 JPY/CO2-ton	62	5.2
	> 5,000 JPY/CO2-ton	24	2.0
	20 times of current Solar Power Generation	14	1.2
	Next generation vehicles	21	1.7
Others		18	1.5
Total		360	30.0%

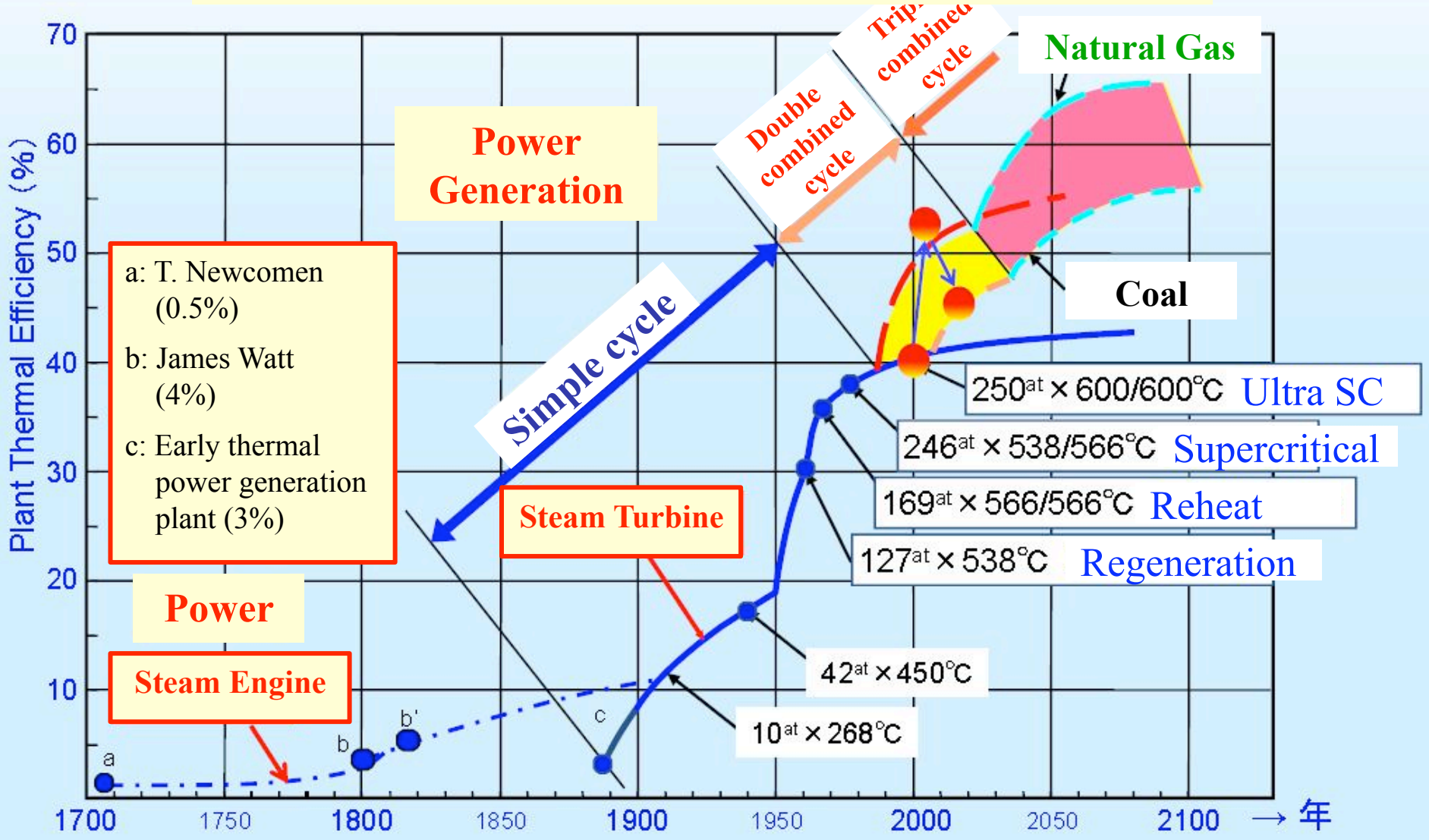
Additional Measures
with Fairness, feasibility and science

- Improvement of capacity utilization rate of nuclear power plant (60%→90%）
- Improvement of the mixed ratio of Biomass in coal-fired power plant (Prpf .S.Kaneko proposes)
- Advanced scheme to globally share the target and technologies. CDM, ETS, and ……

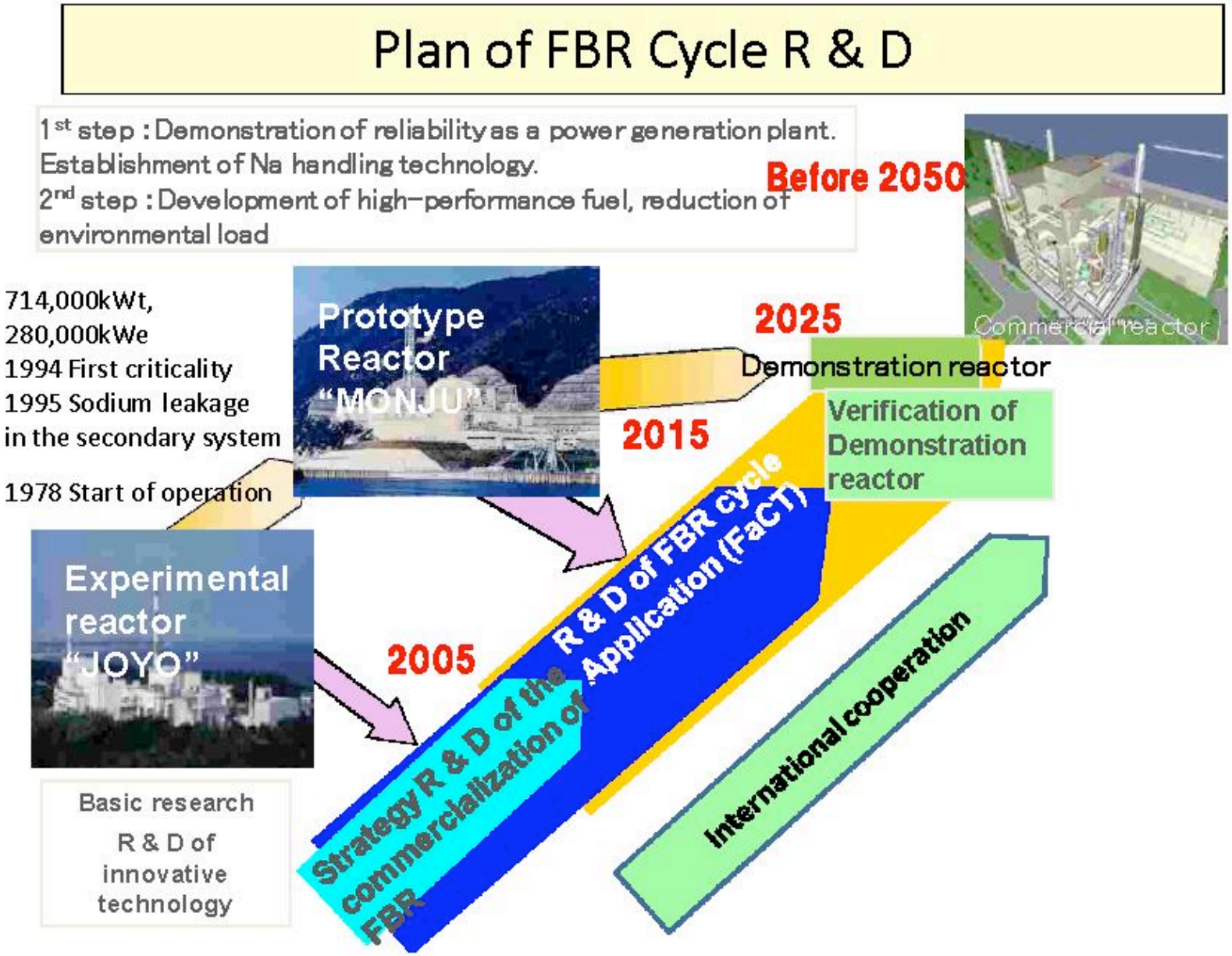
Technologies to Fill in the Gaps

- Green and Efficient thermal power generation technology
- FBR
- Advanced secondary batteries
- Unused renewable energy
  - Cold energy
  - Geothermal energy
  - Thinned wood
- Carbon capture and storage

Evolution of Thermal Efficiency



S. Kaneko, "Thermal Power Generation Technology of Century", *Thermal and Nuclear Power Generation*. Mar. 2004 Vol. 55 No.3 921



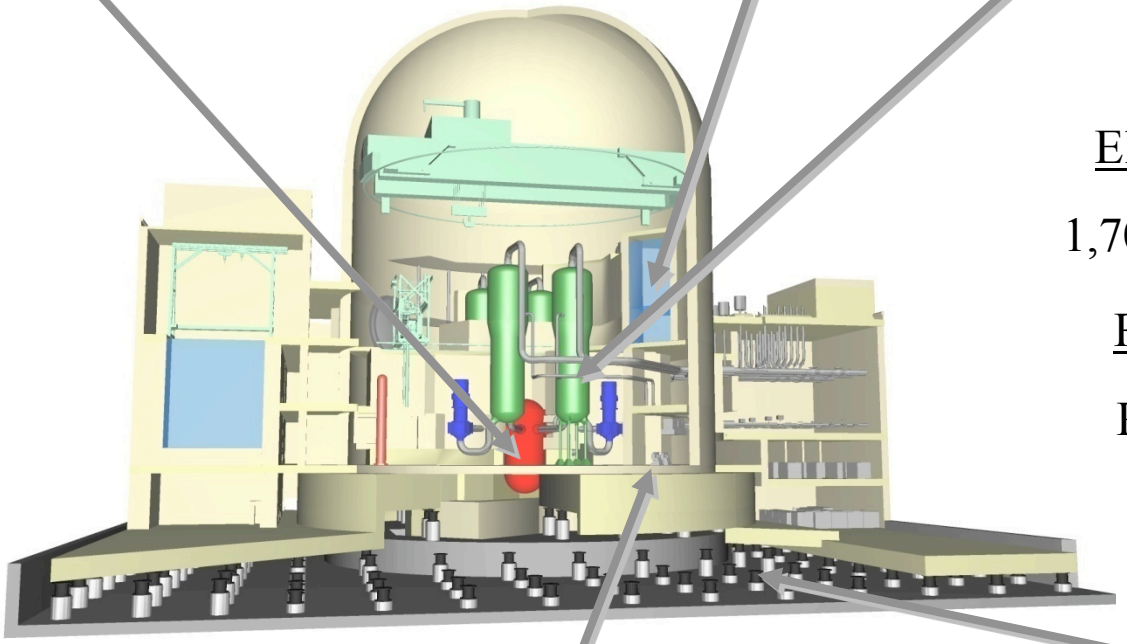
S. Tanaka, "Japan's National Strategy for Global Nuclear Development", ASME/JSME Workshop. October 14, 2009

Overview of Next-Generation LWR

Reactor Core System with above 5% Enriched Uranium Fuel

Hybrid Safety System (optimized passive and active safety)

Long-Life Materials and Innovative Water Chemistry Technologies



Electric Output

1,700–1,800 MWe

Reactor Type

PWR / BWR

World Leading Digital Technology

Innovative Construction Technology

Seismic Isolation System

6 Concepts of Next-Generation LWR

(This Figure shows an example of PWR)

Y. Ueda, "Next-Generation LWR Development Program in Japan", ASME/JSME Workshop. October 14, 2009

HTTR

High Temperature engineering Test Reactor

Feature of HTTR

☆ **Inherent Safety**

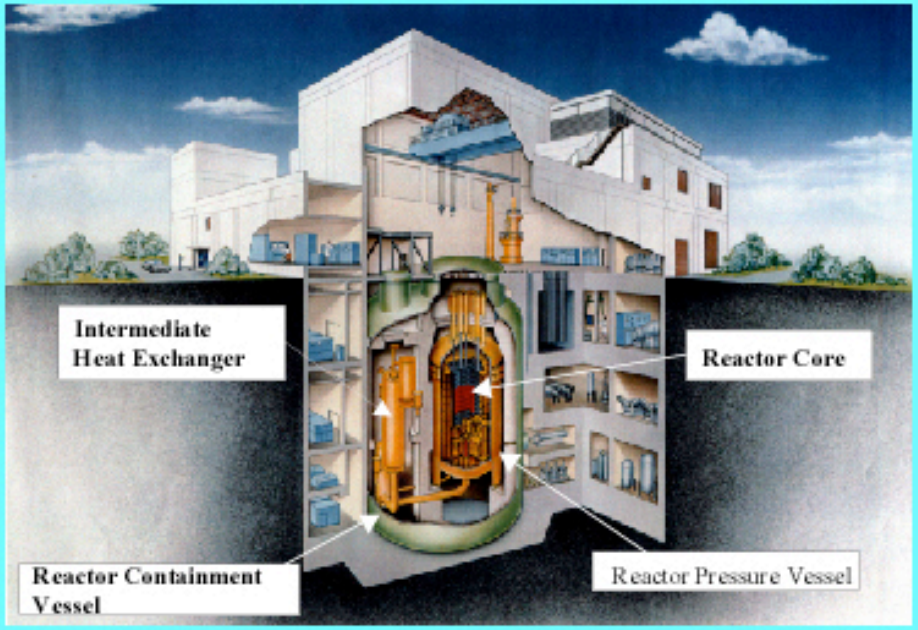
Fuel : Coated fuel particle
Moderator and core internals : Graphite
Coolant: Helium gas

☆ **Reactor outlet temperature : maximum 950℃**

○ **Research on Nuclear heat utilization**

☆ **Wide space for irradiation in high temperature**

○ **Innovative basic research on high temperature technology**



Layout of the HTTR Building

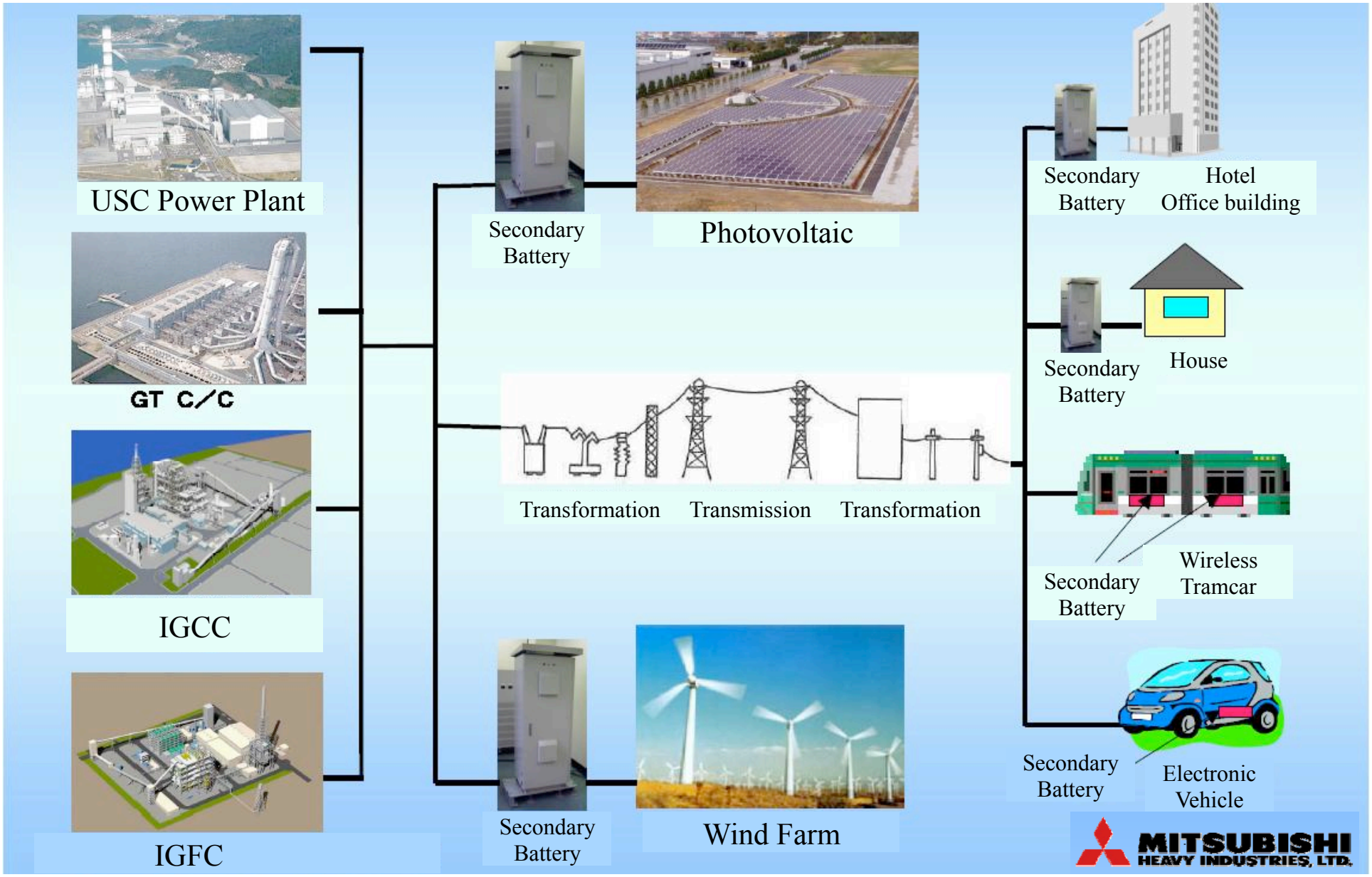
With a thermal power of 30 MW, is a research facility constructed for development of High Temperature Gas-Cooled Reactor (HTGR) technology and nuclear heat utilization technology

The first criticality of the HTTR was attained on November 10, 1998.
The full power of 30 MW and the reactor outlet coolant temperature of 850°C was achieved on December 7, 2001.

The maximum reactor outlet coolant temperature of 950°C was achieved in April 2004.

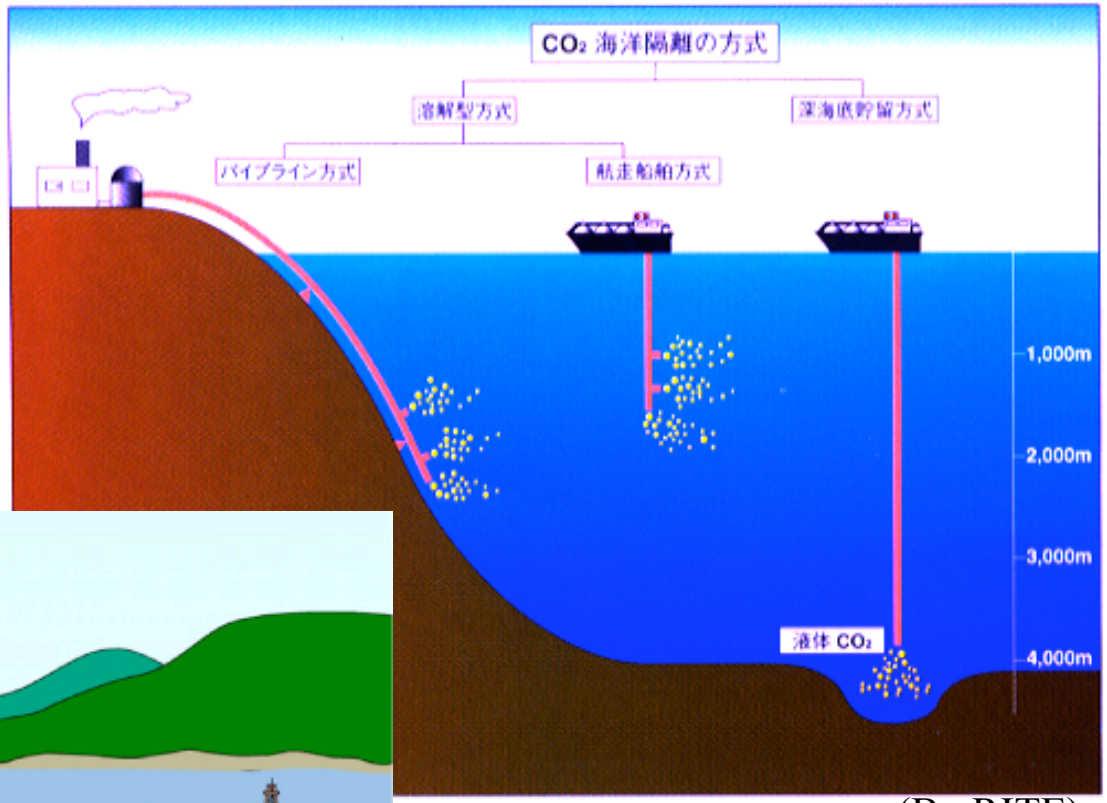
http://httr.jaea.go.jp/eng/index_top_eng.html

Energy Vision based on advanced secondary battery



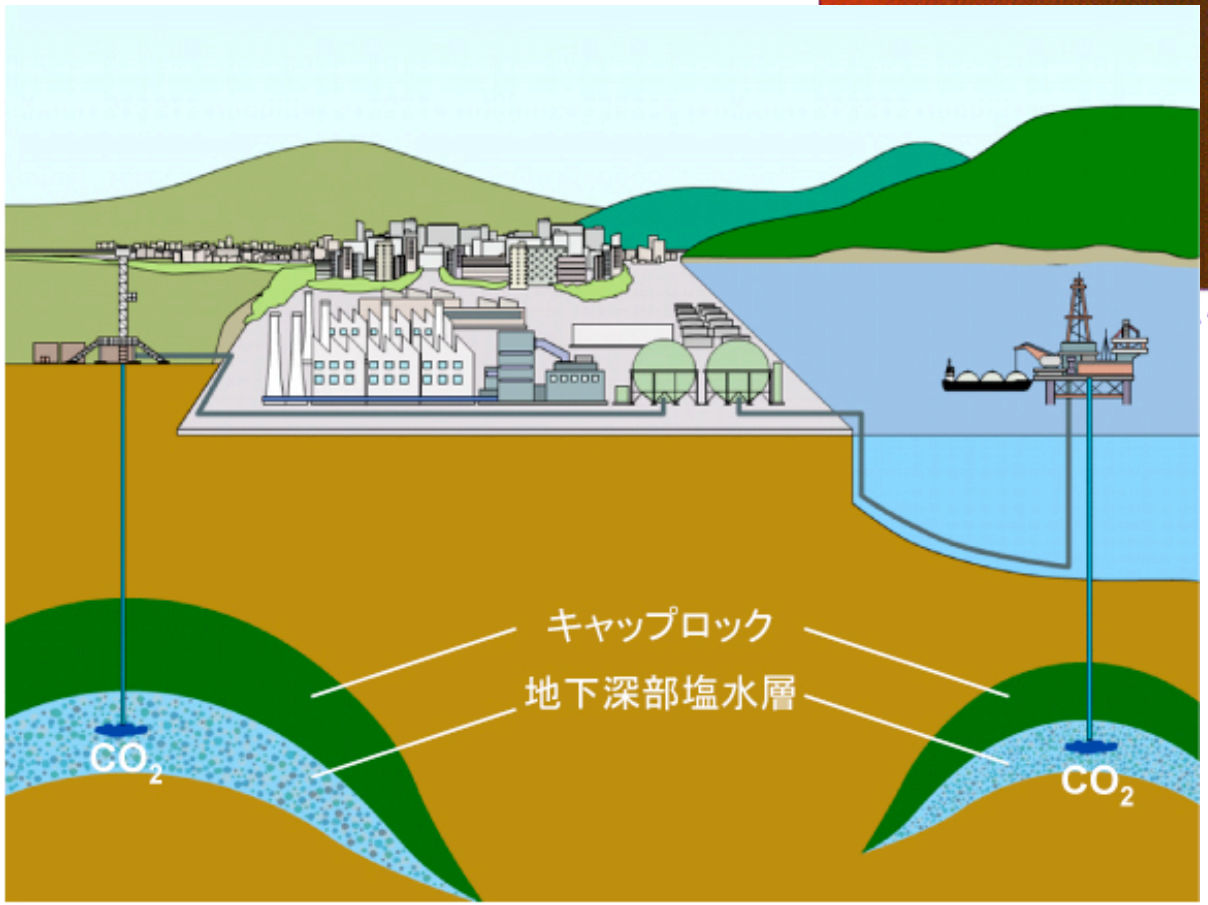
Carbon Capture and Storage (CCS)

Key technology for post combustion



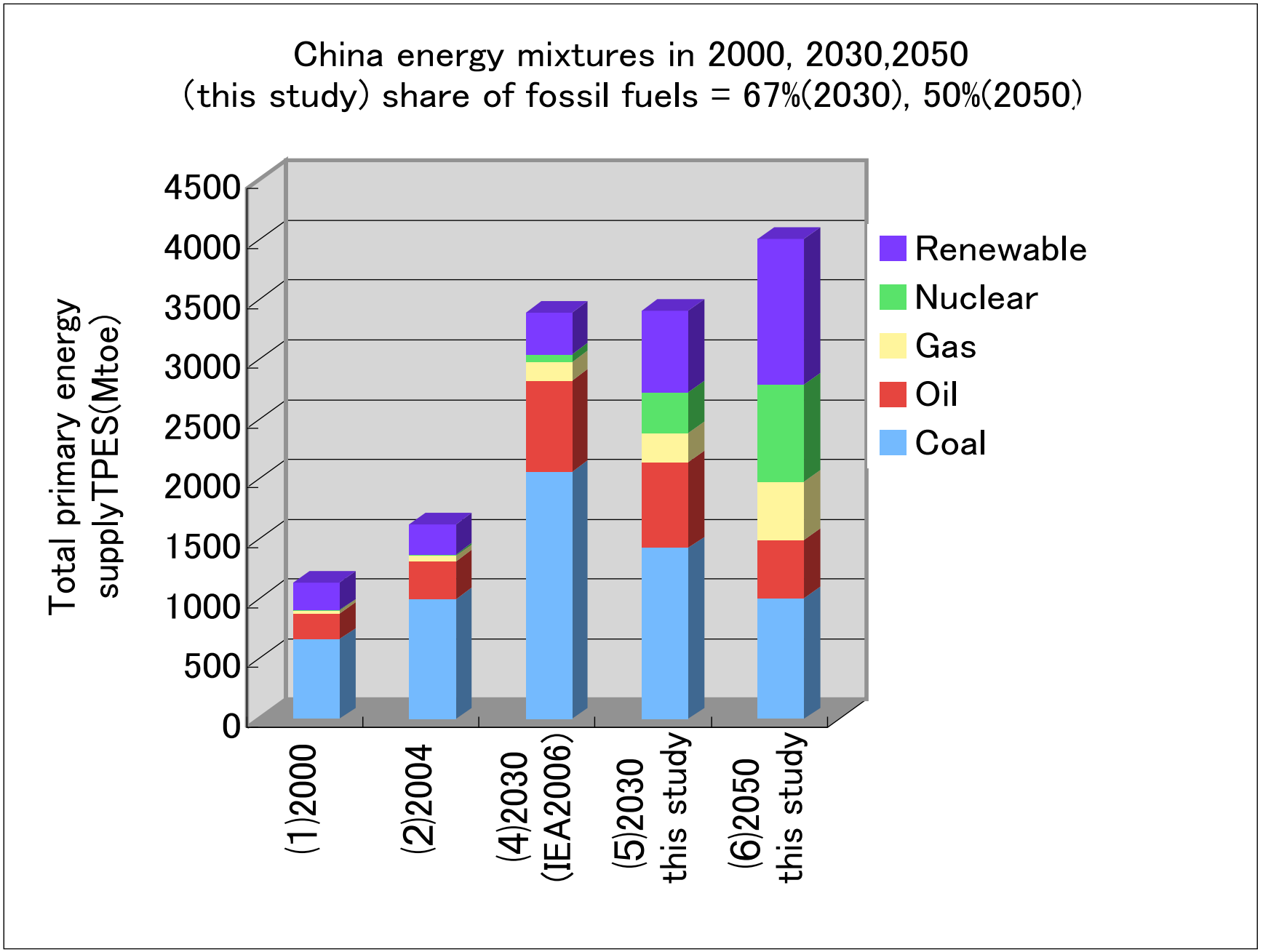
ージ図 (By RITE)

Ocean sequestration



Aquifer sequestration

(By RITE)


China energy mixtures in 2000, 2030,2050
(this study) share of fossil fuels = 67%(2030), 50%(2050)
Total primary energy supplyTPES(Mtoe)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Renewable
Nuclear
Gas
Oil
Coal
(1)2000
(2)2004
(4)2030 (IEA2006)
(5)2030 this study
(6)2050 this study

Aug-2007 T.YUHARA

China : Pathway to 2050 -Mixture of Energy Supply and CO_2 Emission
To make atmospheric CO_2 stable to the level of 500ppm in this century.

JAPAN		ITEM	CHINA			WORLD
2004	**2030**	Year	2004	2030	**2050**	2050
127	**116**	①POPULATION(million)	1302	1460	**1418**	10000
4427	**5810**	②GDP (US$ billion)	1724	14312	**44,453**	99,700
$34,144	**$49,944**	**③GDP per capita (US$)**	$1,324	$9,809	**$31,357**	$12,000
533	**400**	④TPES:Total Primary Energy Supply(Mtoe)	1,626	3,400	**4,000**	18,700
108	**69**	⑤TPES/GDP (toe/M$)	810	237	**89**	188
4.2	**3.4**	**⑥Total Energy per capita(toe/man)**	1.2	2.3	**2.8**	1.9
84:12:4	**50:25:25** **Triple50**	⑦Fuel Mixture % (**Fossil**:**Nuclear**:**Renewable energy**)	84:1:16	**70:10:20**	**50:20:30** **Triple50**	50:20:30
12.17 (1.0)	**6.00 (-0.5)**	⑧CO_2 Emission (100M CO_2 t) (ratio to 2004)	47.7 (1.0)	84.1 (1.8)	**67.0 (1.4)**	268.0
10.0	**5.2**	**⑨CO_2emission per capita (t)**	**3.7**	**5.8**	**4.7**	**2.7**
260	**103**	⑩CO2 emission/GDP(t/M$)	2800	588	**150**	267
41%	**50%**	⑪Rate of Electricity 電力化率	39%	45%	**50%**	--
		⑫Electric generation 総発電量ＴＷｈ	2237	7600	**9600**	
45	**66**	**⑬Nuclear power plant capacity (GW)**	**6**	**160**	**376**	1930
--	**--**	⑭Coal Power-capacity(GW)	307	500	**700**	--

①～④Goldman Sachs, ④WBCSD(World Business Council for Sustainable Development),IEA WEO 2006 等から作成

Proposed for Japan-China forum on environment,energy and transportation issues

Energy balance sheet of China in 2030 (Case-1)

China 2030／Fossil fuels：Nuclear：Renewable＝71:9:19　(Rate of electricity =48.1%)

2030		COAL	OIL	GAS	Nuclear	Hydro	Renewable	Electric	Thermal	Total
Total supply		1430	740	280	320	200	460			3430
Trans	Elect.&thermal	-730		-170	-320	-200	-240 *2	660	90	-910
	Ross	-130	-60	-20				-130	-20	-350
Final consumption *1	Total demands	580	680	100	—	—	220	530	70	2180
	Industry	500	110	40	—	—	20	280	40	1000
	Residential	50	120	60	—	—	190	220	30	660
	Transport		400				10	30		410

* 1．IEA WEO 2006 、except that oil equivalent of hydro power is used by efficiency equal to 40%／2150kcal/kWh

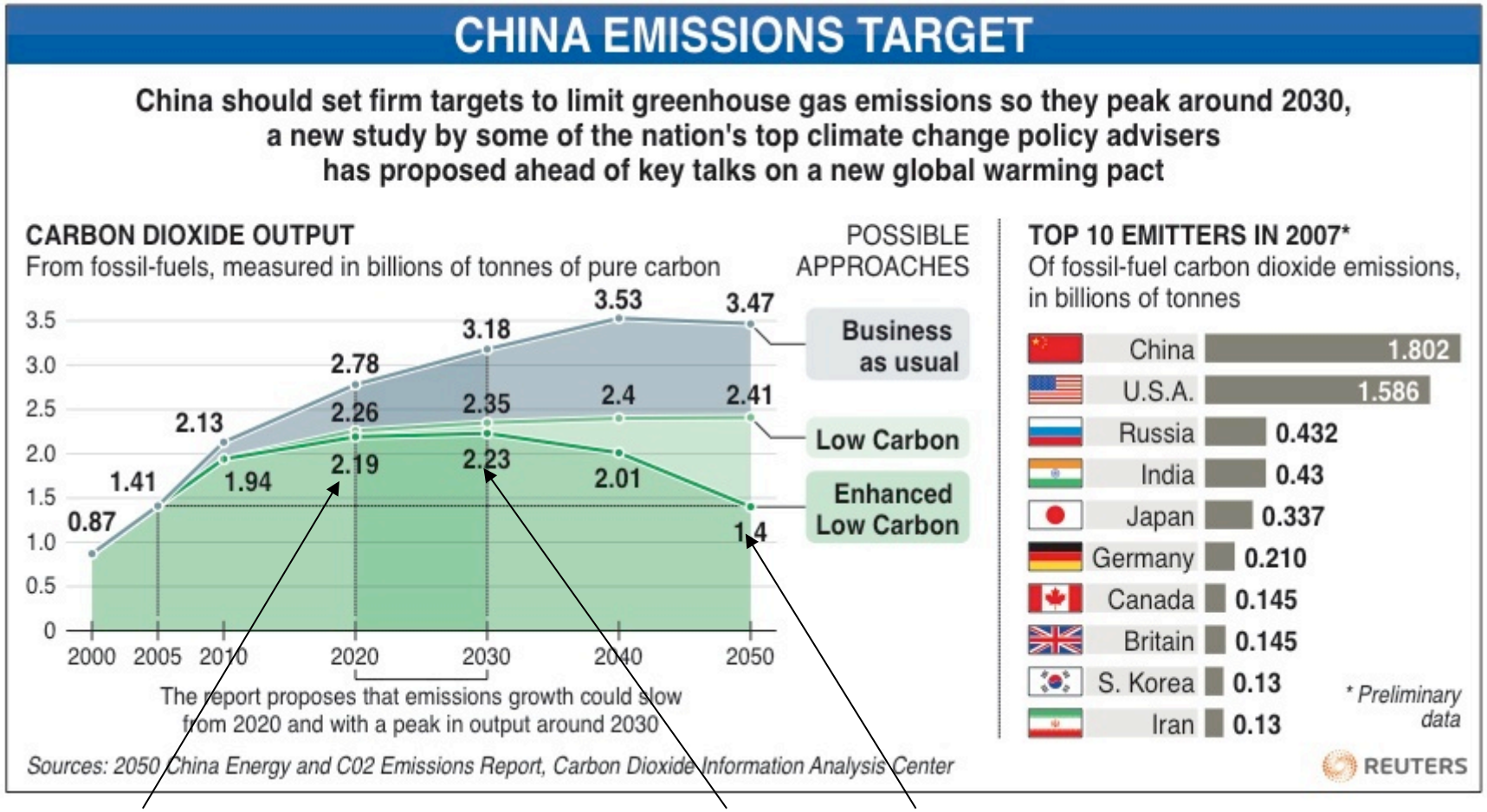
* 2．Renewable energy(except hydro power)　320 GWe

* 3．Energy efficiency　η =40%　in 2030　(25%~30%,in 2005,50%in 2050)。

* 4．If　η ＝35%(IEA 2030、TPES<3200Mtoe (70:10:20)

Resent study of reduction target in China 15 August 2009

Emissions in Enhanced Low Carbon scenario are very similar to Z650 case under 60%-80% reductions by Annex I countries.

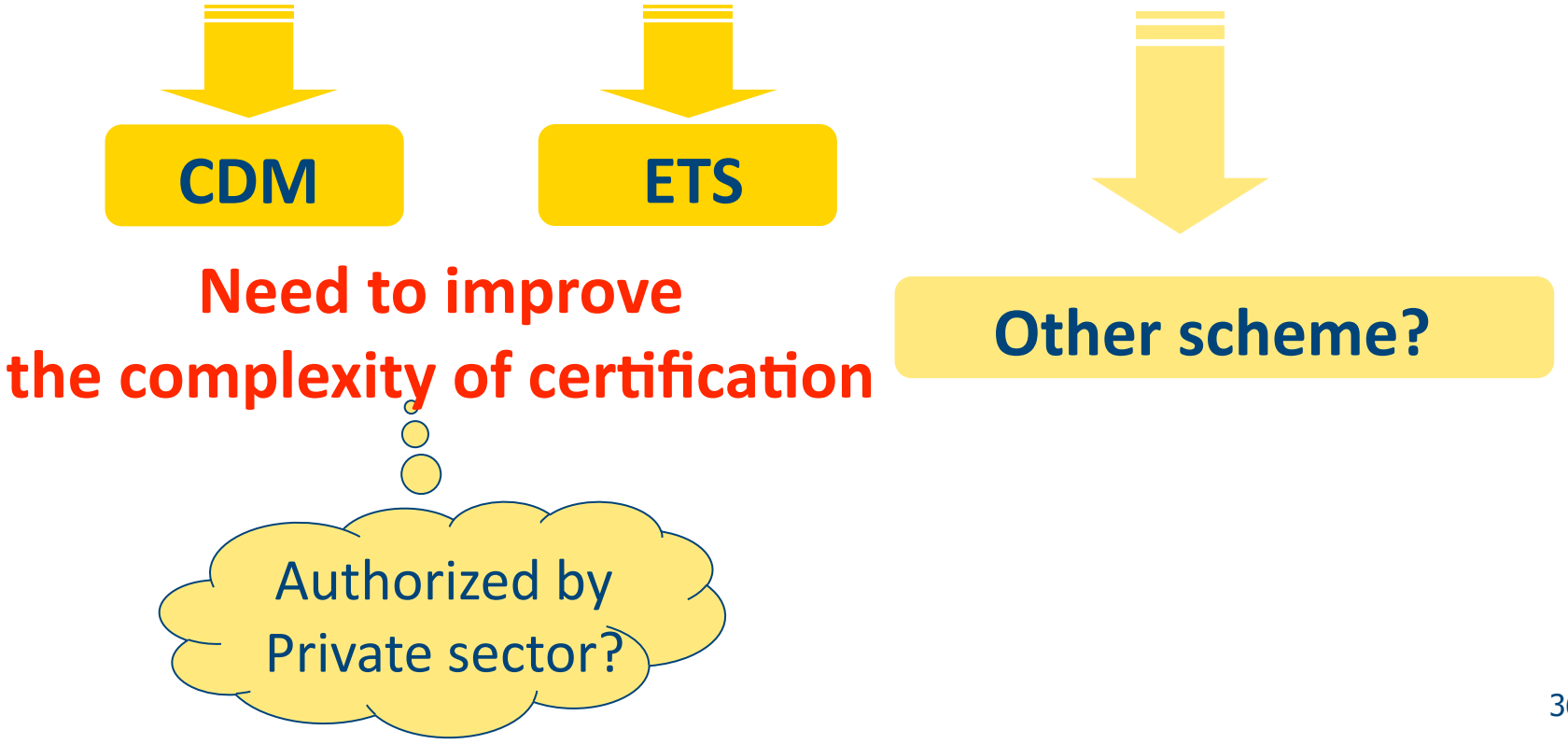


Increase ratio is1.55 in 2020 from 2005 level.

1.58 in 2030 ,,0.99 in 2050

Harmony among Asia (with China)

- Sharing the target
- Advanced schemes to accelerate sharing advanced technologies among countries.



Thank you for your attention.