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Analyses on Japanese Emissions Reduction Scenarios and Policy Trends

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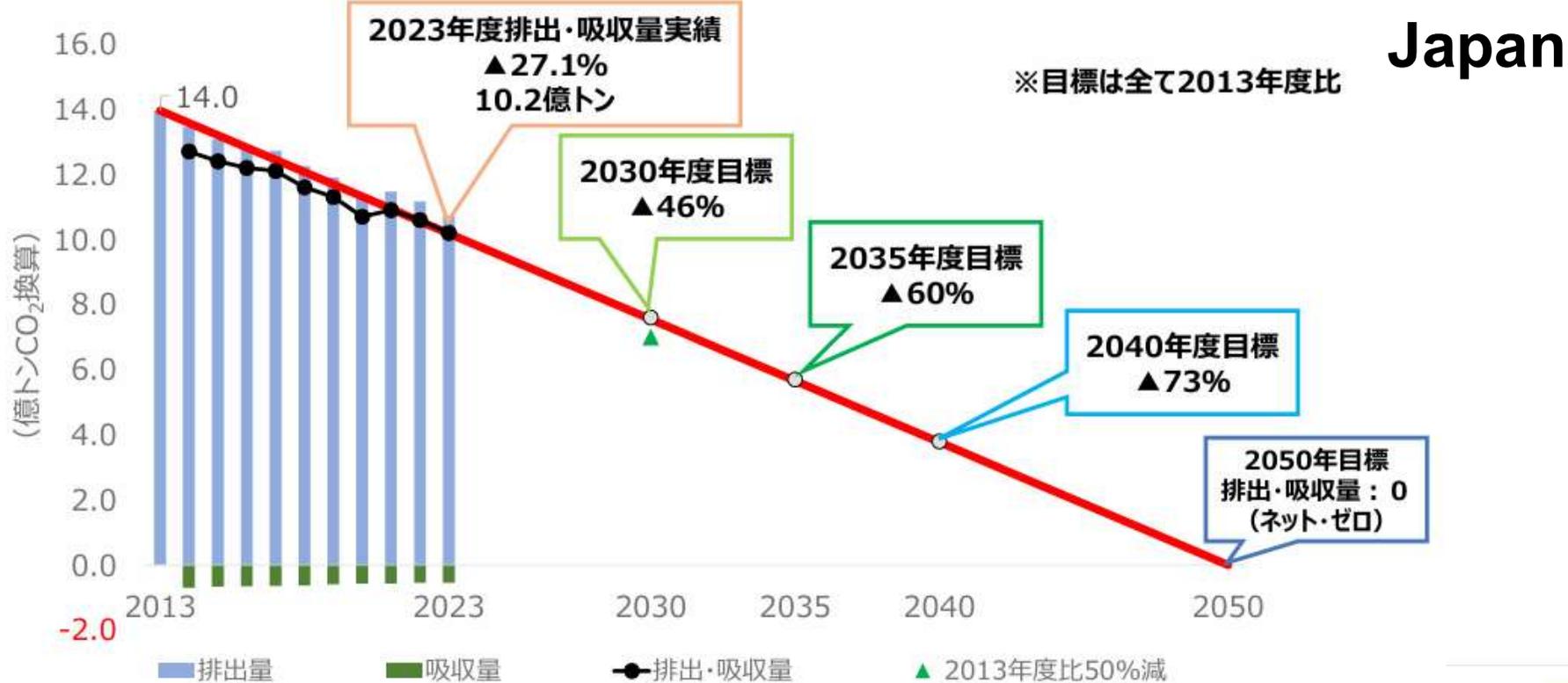
**Research Institute of Innovative Technology for the Earth
(RITE)**



1. Emissions Reduction Trends and NDCs in Japan



The Trends of Emissions Reductions and NDCs in Japan



Emissions from Industry



Source) The Government of Japan (2025)

2. Evaluation of NDCs in 2035



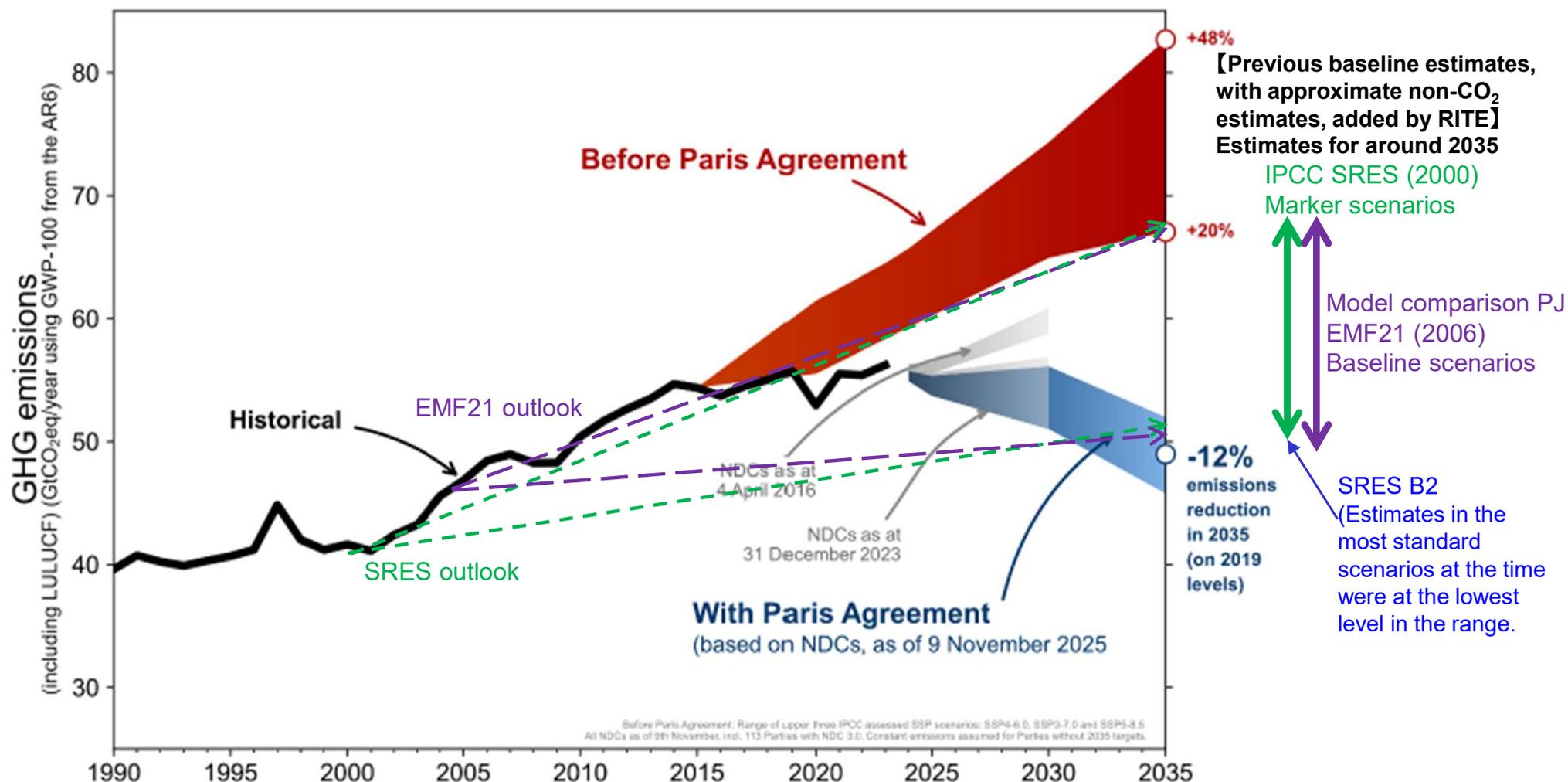
Emissions reduction targets by major countries' NDCs

Analysis by RITE was conducted over NDCs submitted as NDC3.0 before Dec. 31, 2025

	2030 NDC	2035 NDC	2040 NDC	2050 -
Japan	-46% (vs 2013)	-60%	-73%	CN by 2050
US*	-50% to -52% (vs 2005)	-61% to -66%	—	CN by 2050
EU27	-55% (vs 1990)	-66.25% to -72.5%	-90%	CN by 2050
UK	-68% (vs 1990)	-81%	—	CN by 2050
Switzerland	-50% (vs 1990)	At least -65%	At least -75%	CN by 2050
Norway	-55% (vs 1990)	-70% to -75%	—	Low emission society by 2050
Australia	-43% (vs 2005)	-62% to -70%	—	CN by 2050
New Zealand	-50% (vs 2005)	-51% to -55%	—	CN by 2050 (w/o methane)
Canada	-40% to -45% (vs 2005)	-45% to -50%	—	CN by 2050
Russia	-30% (vs 1990)	-65% to -67%	—	CN by 2060
Korea	-40% (vs 2018)	-53% to -61%	—	CN by 2050
China	-65% CO ₂ emissions per GDP (vs 2005)	-7% to -10% vs GHG emissions peak (peaking before 2030)	—	CN by 2060
India	-45% GHG emissions per GDP (vs 2005)	—	—	CN by 2070

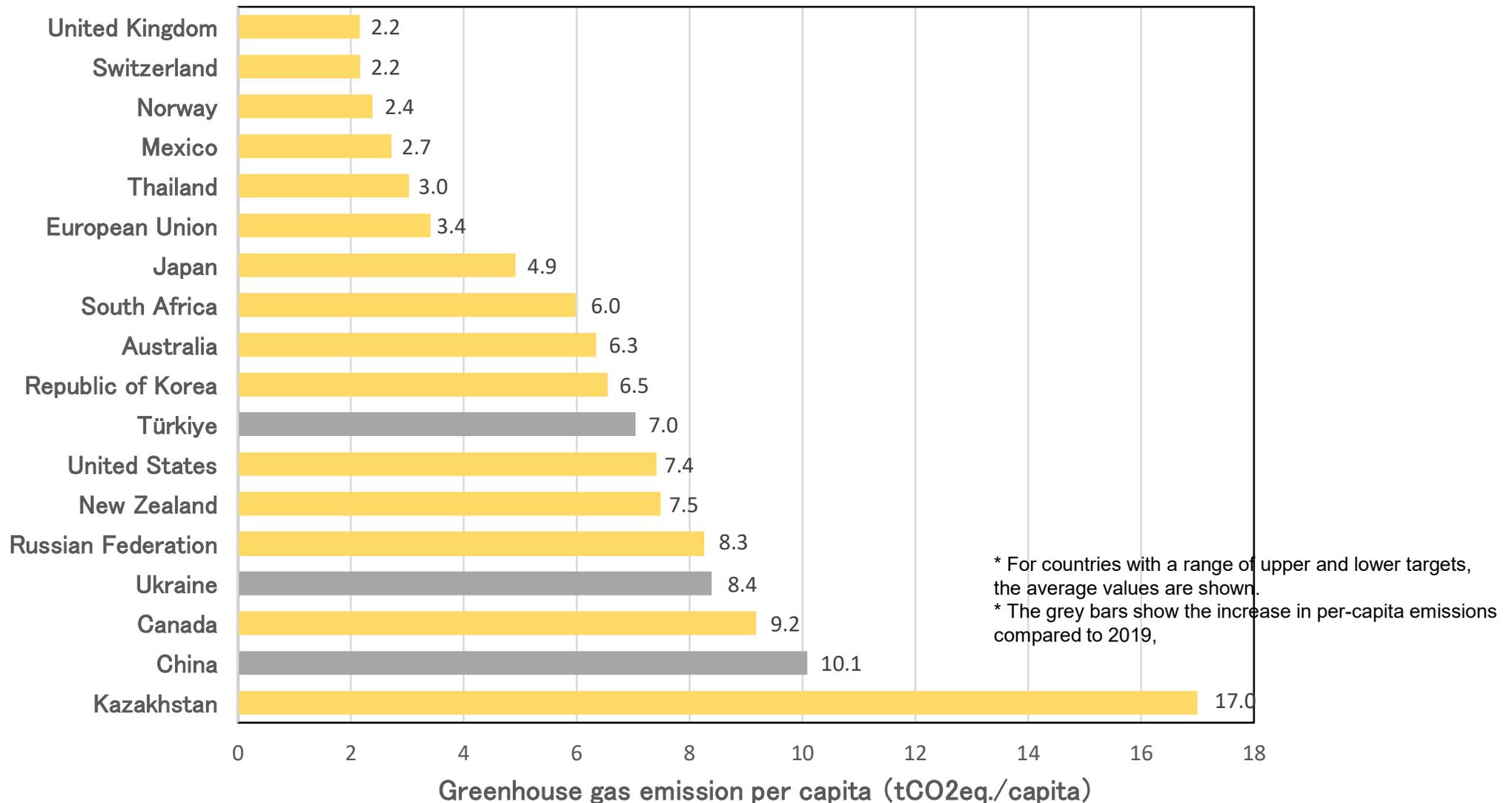
* Submitted by the Biden administration. Withdrawn from the Paris agreement on Jan. 26, 2026

Emissions based on new NDCs submitted by Nov.9, 2025



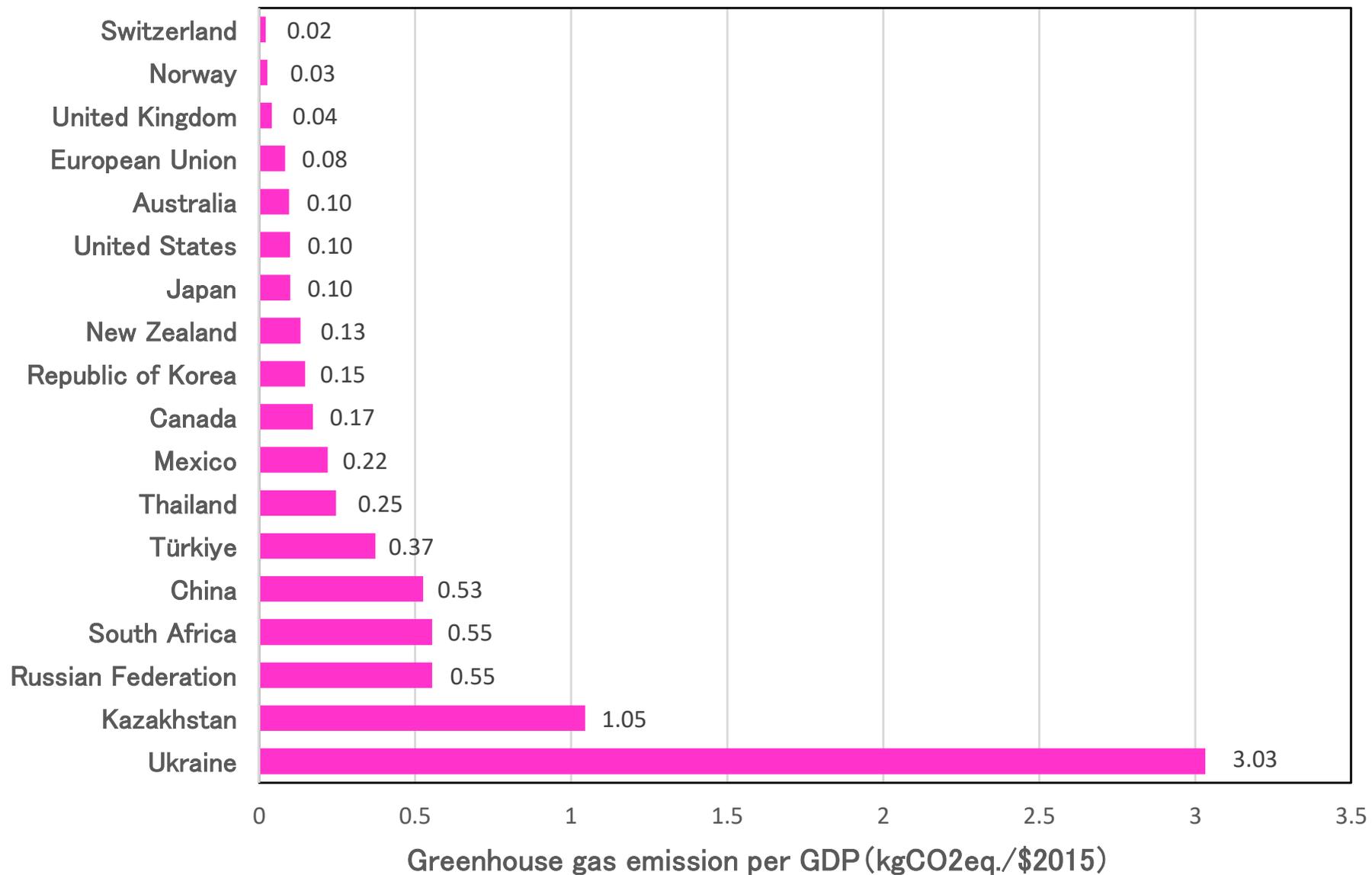
- ✓ Based on the new NDCs submitted by 113 Parties as of Nov. 9, 2025, GHG emissions (with LULUCF) in 2035 are projected to be around 12% below 2019 levels.
- ✓ The prediction of "Before Paris Agreement" should be carefully evaluated. The BaU emissions estimates in the previous studies in IPCC were not as high as this. Actual emissions have not been reduced. The results of UNFCCC's effort may be overstated.

International comparison of per-capita GHG emissions in 2035 for NDCs



- ✓ **GHG emissions per capita of UK is the smallest among the counties in scope, followed by Switzerland and Norway.**
- ✓ **Emissions per capita in Türkiye, Ukraine, and China likely continue to rise.**
- ✓ **The estimates of emissions are production-based, not consumption-based, and depend greatly on the industrial structure.**

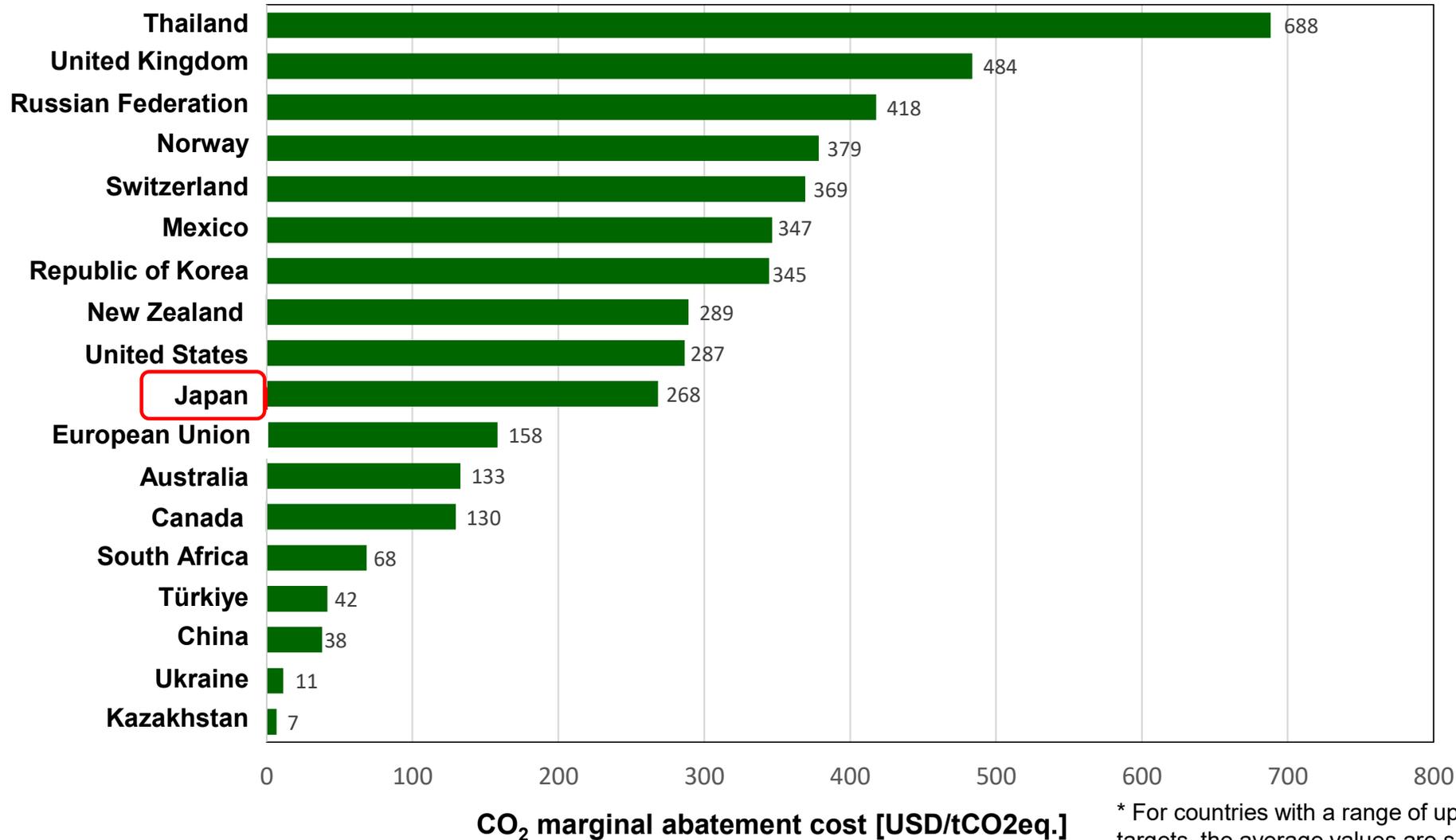
International comparison of per-GDP GHG emissions in 2035 for NDCs



* For countries with a range of upper and lower targets, the average values are shown.

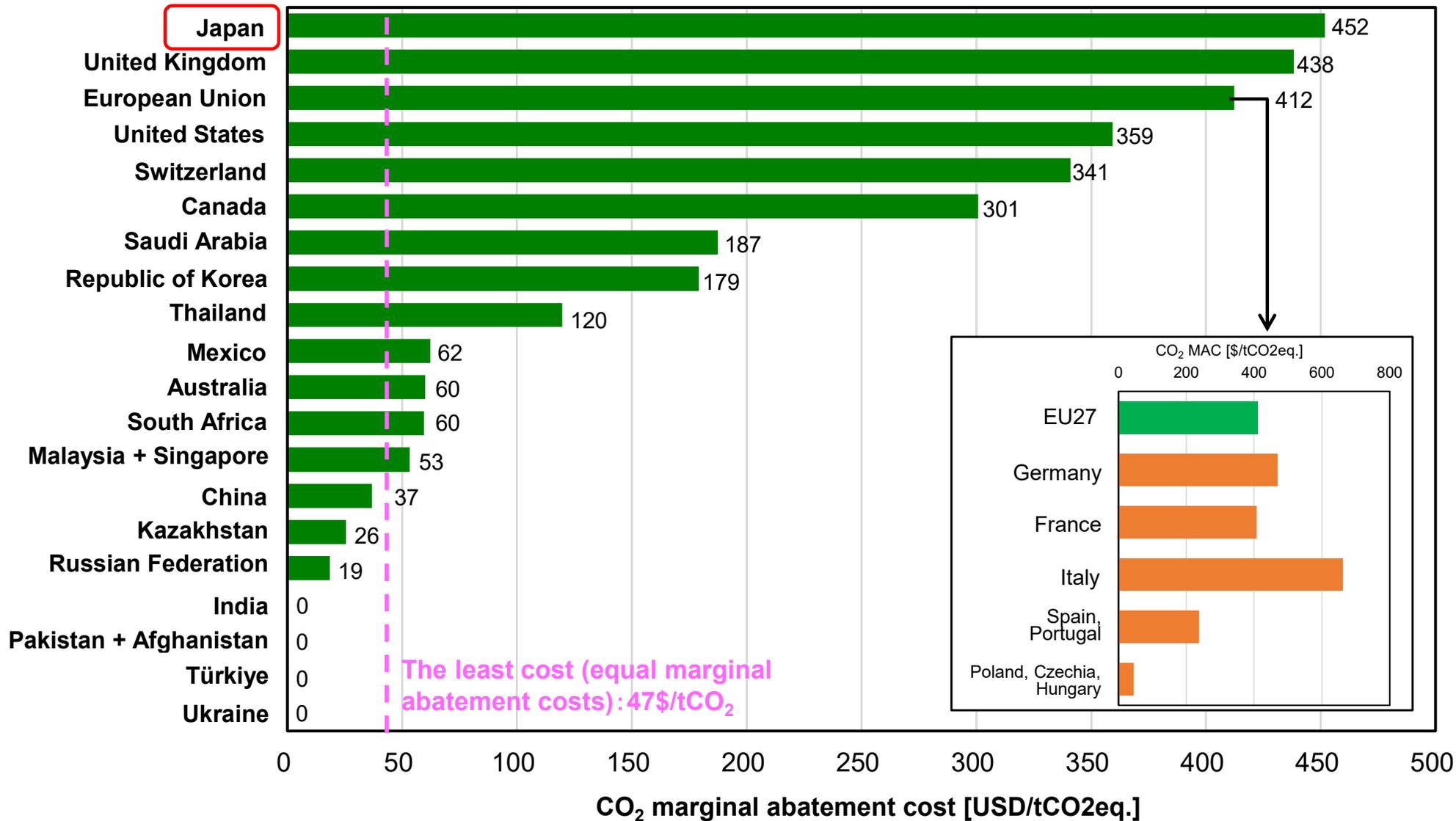
✓ **GHG emissions per GDP are the lowest in Switzerland, Norway, and UK in that order (the values tend to be lower for the countries with a large proportion of tertiary industry, and higher for the countries with a large proportion of secondary industry).**

International comparison of CO₂ MAC in 2035 for NDCs



- ✓ CO₂ MACs of Thailand, UK, and Russia are high. While CO₂ MACs of many countries are high from 100 to a few hundreds dollars per tCO₂, those of some other countries are low, leading to a risk of carbon leakage due to those huge differences.
- ✓ CO₂ MACs of EU, Switzerland, and Japan, which have 2040 emissions reduction targets, are 387, 318, and 368\$/tCO₂, respectively, in 2040.

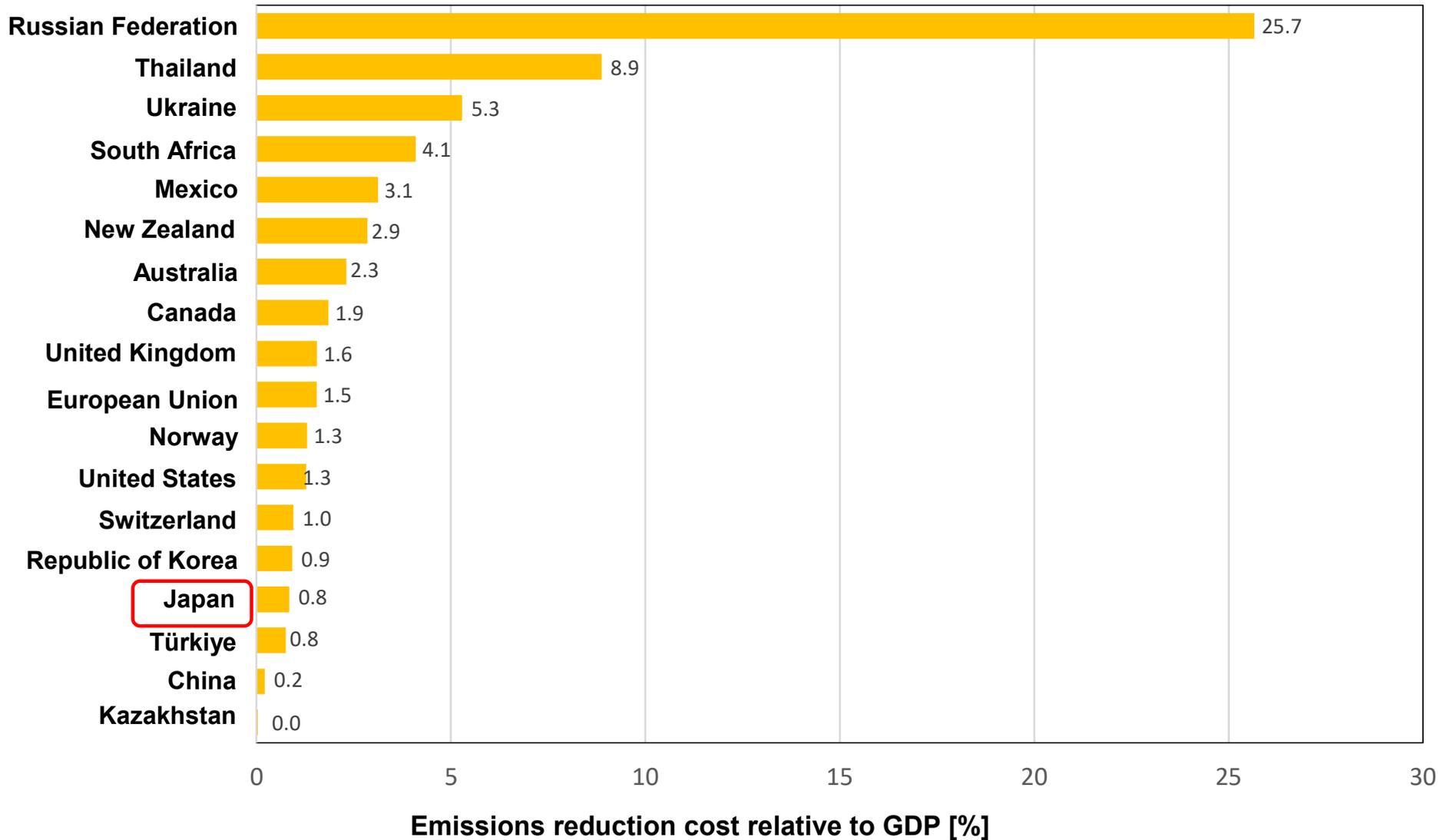
International comparison of CO₂ MAC in 2030 for NDCs



Note) Brazil and Indonesia are not evaluated as LULUCF's contributions to emissions are large including huge uncertainties. Iran is also not evaluated since uncertainty around the definition of BAU is significant.

✓ **The estimates of CO₂ MACs of Japan, US, and European countries are extremely high while those of developing countries are low. In particular, CO₂ MACs of India, Pakistan, and Türkiye, etc. are estimated to be zero.**

International comparison of per-GDP emissions reduction costs

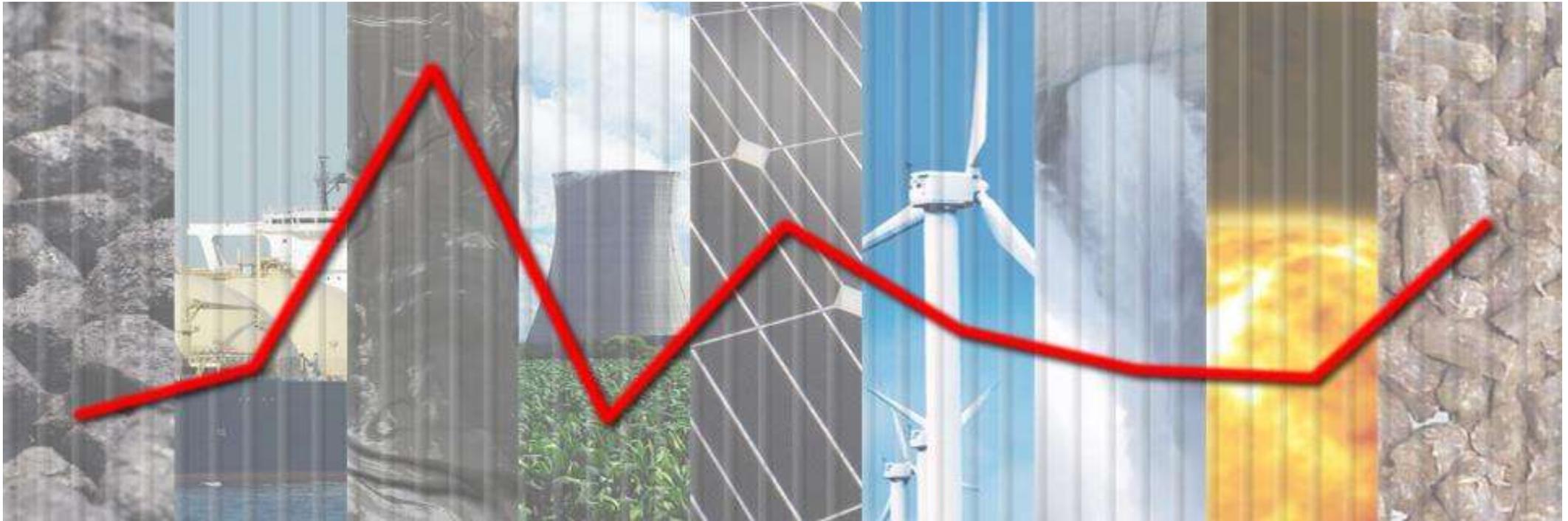


* For countries with a range of upper and lower targets, the average values are shown.

- ✓ Emissions reduction costs per GDP of Russia, Thailand, and Ukraine are high.
- ✓ It seems more countries decide emissions reduction goals not considering the feasibility.

3. Analyses for the 7th Strategic Energy Plan and a sensitivity analysis based on global trends

Supply-demand outlook in the 7th strategic energy plan in Japan (Feb. 2025) is based on the scenario analysis by RITE.



Energy Assessment Model: DNE21+

(Dynamic New Earth 21+)

- ◆ Systemic cost evaluation on energy and CO₂ reduction technologies is possible.
- ◆ Linear programming model (minimizing world energy system cost; with 10mil. variables and 10mil. constrained conditions)
- ◆ Evaluation time period: 2000-2100
Representative time points: 2005, 2010, 2015, 2020, 2025, 2030, 2040, 2050, 2070 and 2100
- ◆ World divided into 54 regions
Large area countries, e.g., US and China, are further disaggregated, totaling 77 world regions.
- ◆ Interregional trade: coal, crude oil/oil products, natural gas/syn. methane, electricity, ethanol, hydrogen, CO₂ (provided that external transfer of CO₂ is not assumed in the baseline)
- ◆ Bottom-up modeling for technologies on energy supply side (e.g., power sector) and CCUS
- ◆ For energy demand side, bottom-up modeling conducted for the industry sector including steel, cement, paper, chemicals and aluminum, the transport sector, and a part of the residential & commercial sector, considering CGS for other industry and residential & commercial sectors.
- ◆ Bottom-up modeling for international marine bunker and aviation.
- ◆ Around 500 specific technologies are modeled, with lifetime of equipment considered.
- ◆ Top-down modeling for others (energy saving effect is estimated using long-term price elasticity.)

- **Regional and sectoral technological information provided in detail enough to analyze consistently.**
- **Analyses on non-CO₂ GHG possible with another model RITE has developed based on US EPA's assumptions.**

- **Model based analyses and evaluation provide recommendation for discussions on some energy and climate change policy making processes, e.g., cap-and-trade system, Environmental Energy Technology Innovation Plan, 6th Energy Strategic Plan for the Government of Japan, and also contribute to IPCC scenario analyses.**

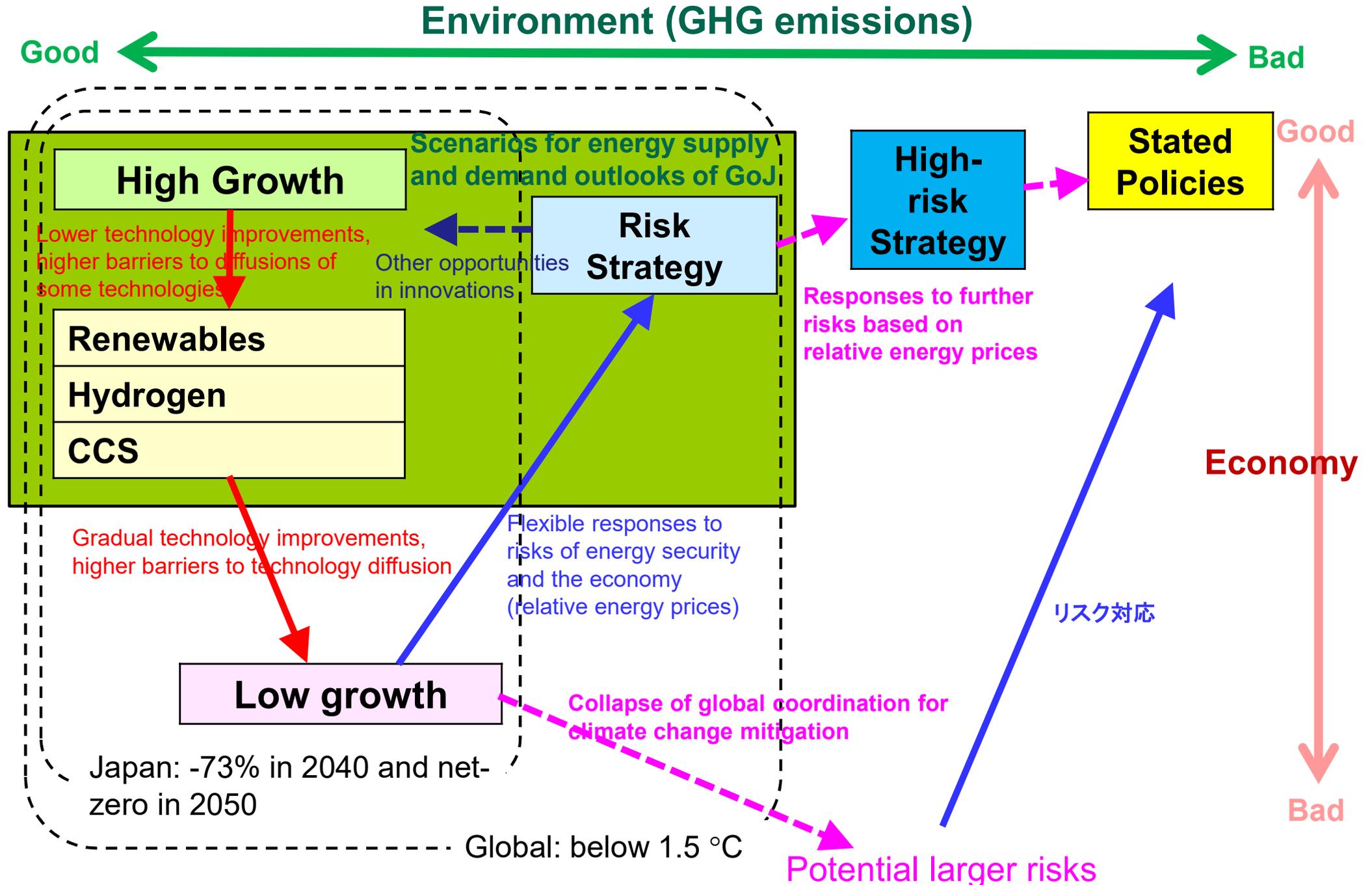
Overview of the Scenarios

Emissions scenarios	Scenario name	Scenario descriptions
<p>Emissions reduction scenarios:</p> <p>2030: -46% 2040: -73% 2050: -100%</p> <p>[World] Below 1.5 °C</p>	<p>High Growth [Innovative technology expansion]</p>	<p>Broad mitigation technologies advance rapidly and expand internationally. Gaps between the relative prices of energy in Japan and other countries are moderate. A virtuous cycle between the economy and the environment.</p>
	<p>Renewables [Renewable expansion]</p>	<p>High social acceptance and rapid cost reduction of renewables</p>
	<p>Hydrogen [Hydrogen and new fuels deployment]</p>	<p>Rapid cost reductions in hydrogen, including ammonia, e-methane, and e-fuels</p>
	<p>CCS [CCS deployment]</p>	<p>Lower social barriers to geological CO₂ storage</p>
	<p>Low Growth [-]</p>	<p>Incremental technology improvements. The relative prices of energy in Japan will increase. Relocation of industries to abroad, an emerging risks for economic stagnation</p>
<p>Carbon price scenarios:</p> <p>Risk-responding scenario with a virtuous cycle between the economy and the environment under the uncertainties of technology improvements. -73% in 2040 and CN in 2050 as policy targets, but focused more on mitigation costs, leading to changes in the emissions under uncertainties</p>	<p>Risk Strategy [Technology Improvement]</p>	<p>Technology improvements are conservative, leading to the increase in relative energy prices in Japan. Restrictive carbon price policies are taken to maintain a virtuous cycle of the economy and the environment. Carbon prices are assumed based on the NGFS NZE2050 scenarios.</p>
	<p>High-risk Strategy [-]</p>	<p>Same as above, except for the assumption of the carbon price which refers to the IEA NZE</p>
<p>Carbon price scenario:</p> <p>Enhanced priority on the economy. Withdrawal from 1.5 °C and CN by 2050. Only pledged policies are implemented.</p>	<p>Stated policies scenario [-] Note) The red parentheses</p>	<p>Same as above, except for the assumption of the carbon price which refers to the IEA STEPS</p> <p>show the scenario labels in the 7th Strategic Energy Plan.</p>

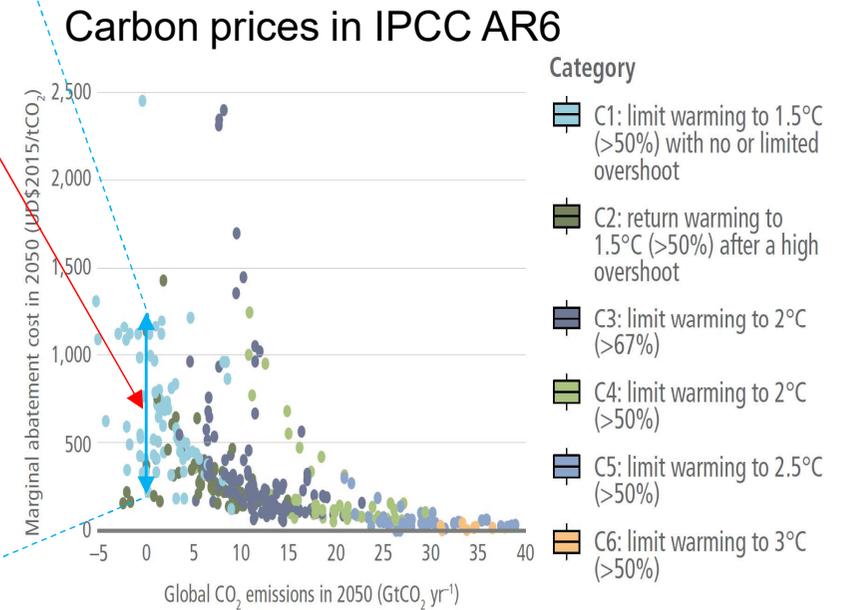
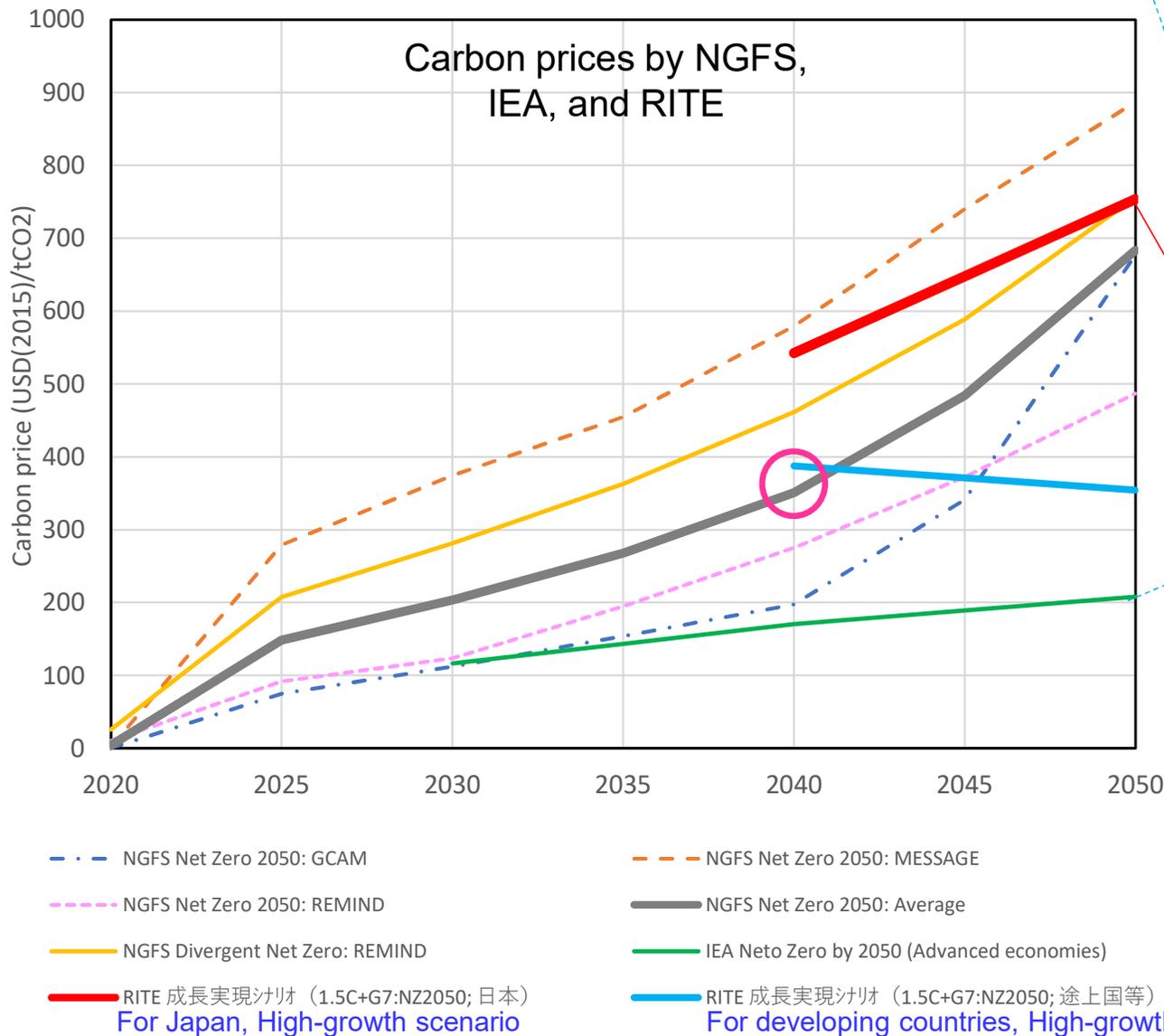
Scenario Assumptions by RITE

Scenarios	Potential economic growth	GHG emissions	Nuclear	Renewables		CCS/CDR	Hydrogen/ammonia	e-fuels/e-methane	IT electricity demands	Automobiles	Iron and steel	EITE and car production reductions due to energy price increase including relative prices	
	Income, population, and baseline industrial structure changes	Carbon prices due to emissions reduction	[Upper bound] Low: Existing 60 yrs operation reactors only/ Mid: 20% in 2040; 10% in 2050/ High: 20%	[Upper potential considering social acceptance] Low: double of the current deployment level of solar PV, and three times for onshore wind power/ High: four times as the current deployment levels both of PV and onshore wind power	[Cost] Mid./ Rapid cost red.	[Upper bound] Annual potentials of geological storage (2050) Low: 0.12 Gt/ High: 0.24 Gt	[Cost] Mid./ Rapid cost red.	[Cost] Mid./ Rapid cost red.	Exogenous outlook	[EV cost] Mid./ Rapid cost red.	Diffusion constraints of hydrogen DRI		
High growth	The official ambitious target by the GoJ	[World] 1.5°C target	High	High (Economical potential: Mid)	Rapid cost red.	High	Rapid cost red.	Rapid cost red.	High	Rapid cost red.	High	Low (mid. price elasticity (CGE model: DEARS))	
Renewables			Mid	High (Economical potential: Mid)	Rapid cost red.	Low	Mid	Mid	High	Rapid cost red.	High		
Hydrogen			[Japan] 2030: -46%	Mid	High	Mid	Low	Rapid cost red.	Rapid cost red.	High	Mid		High
CCS			2040: -73%	Mid	High	Mid	High	Mid	Mid	High	Mid		High
Low growth (Ref.)			2050: -100%	Low	Low	Mid	Low	Mid	Mid	Mid	Mid		Mid
Risk strategy		Carbon price: NGFS NZ2050	Mid	High	Mid	Low	Mid	Mid	High	Mid	Mid	Low	

Map of the scenarios



Assumption of carbon prices in the Risk-Strategy Scenario (1.5°C / CN by 2050)



Notes:

NGFS: Network for Greening the Financial System

Carbon prices are converted into 2015 prices using US CPI

IEA NZE scenario is well-known, with particularly low carbon prices estimated

- ✓ **NGFS uses three models to develop scenarios. The Marginal abatement cost (MAC) of CO₂ in the High growth scenario by RITE is similar to that of Divergent Net Zero by the REMIND model.**
- ✓ **The average of MAC by three models in the Net Zero 2050 scenario is slightly lower, which is used to estimate emissions in Japan in the Risk-strategy scenario.**

Carbon prices in IEA WEO scenarios and assumptions for the High-risk Strategy scenario and the Stated policies scenario

USD (2023, MER) per tonne of CO ₂	2030	2035	2040	2050
Stated Policies Scenario	Carbon prices assumption in the Stated Policies Scenario			
Canada	126	126	126	126
Chile and Colombia	21	24	28	28
China	39	43	46	52
European Union	140	145	149	158
Korea	56	65	73	89
Announced Pledges Scenario	Carbon prices for Korea are employed for Japan			
Advanced economies with net zero emissions pledges*	135	160	175	200
Selected emerging market and developing economies with net zero emissions pledges**	40	65	110	160
Other emerging market and developing economies	-	6	17	47
Net Zero Emissions by 2050 Scenario	Carbon prices assumption in the High-Risk Strategy Scenario			
Advanced economies with net zero emissions pledges*	140	180	205	250
Selected emerging market and developing economies with net zero emissions pledges**	90	125	160	200
Selected emerging market and developing economies without net zero emissions pledges	25	50	85	180
Other emerging market and developing economies	15	25	35	55

* Includes all OECD countries except Mexico. ** Includes China, India, Indonesia, Brazil and South Africa. *** Regions excluding OECD countries, selected emerging market and developing economies with net zero emissions pledges, developing Asia and sub-Saharan Africa.

Note: MER = market exchange rate. Values are rounded.

Global emissions and temperature rise

	GHG emissions reduction in 2040 (relative to 2019)	Net-zero timing of CO ₂ emissions	Temperature rise compared with the pre-industrial level		
			Peak	2100	
IPCC C1: 1.5°C with no or limited overshoot	69 [58–90] %	2050–55	1.6°C [1.4–1.6]	1.3°C [1.1–1.5]	
IPCC C2: 1.5°C with high overshoot	55 [40–71] %	2055–60	1.7°C [1.5–1.8]	1.4°C [1.2–1.5]	
Scenarios in this analysis	-73% in 2040 and net-zero in 2050	62 % (energy CO ₂ : 71–72%)	2050–55	1.7°C	1.4°C
	Carbon price scenario (Risk strategy)	52 % (energy CO ₂ : 54%)	2050–55	1.7°C	1.5°C
	Carbon price scenario (High-risk strategy)	24% (Energy CO ₂ : 8%)	— (2100-)	2.4°C	2.4°C
	Stated policies scenario	1% (Energy CO ₂ : -28%)	— (2100-)	3.2°C	3.2°C

Scenarios for Strategic Energy Plan

The marginal abatement cost of CO₂

		Emissions reduction scenario (-73% in 2040)					Carbon prices scenario		
		High growth	Renewables	Hydrogen	CCS	Low growth	Risk strategy	High risk strategy	Stated policies
Japan	2040	301	369	467	396	538	257	116	41
	2050	578	716	742	892	951	500	141	50
US	2040	294	350	409	362	410	257	116	0
	2050	262	348	454	350	467	500	141	0
UK	2040	294	350	419	369	428	257	116	84
	2050	317	387	558	452	579	500	141	89
EU	2040	298	350	409	362	410	257	116	84
	2050	413	516	648	541	664	500	141	89
Others	2040	294	350	409	362	410	257	20~116	0~84
	2050	262	348	454	350	467	500	31~141	0~89

Unit: USD/tCO₂ (in 2000 price)

✓ From the perspective of current global trends and to prevent accompanying industrial leakage, it is necessary to consider the carbon price levels in two additional carbon price scenarios analyzed here.

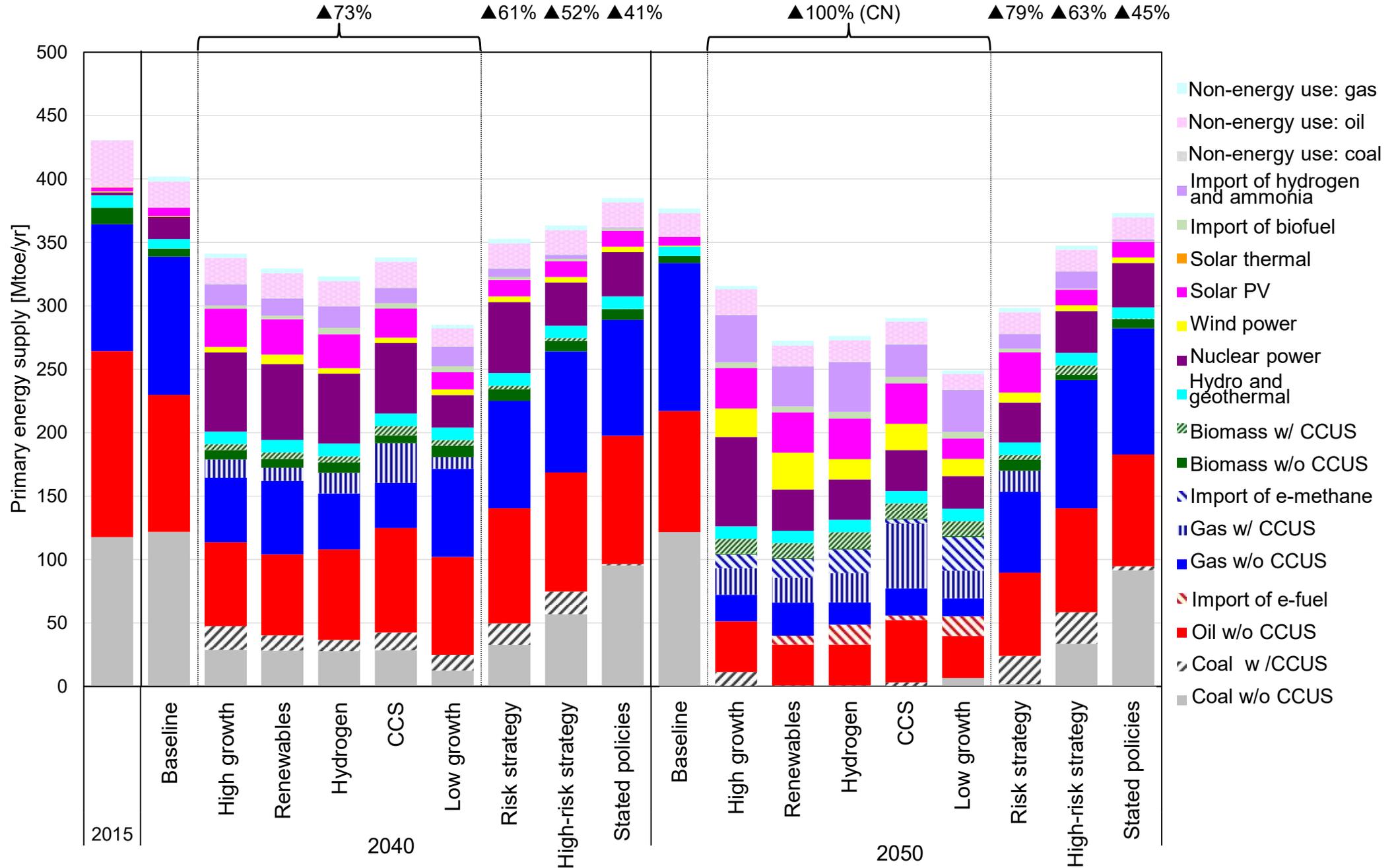
GDP and major manufacturing industries in Japan

Reduction ratios in productions/value added	High Growth (DEARS)		Low Growth (price elasticity: -1.0, income elasticity: +1.0, and RAS)		Risk Strategy (DEARS)		High-Risk Strategy (DEARS)	
	2040	2050	2040	2050	2040	2050	2040	2050
Iron and steel	-3.9%	-11.0%	-41%	-46%	-3.6%	-11.0%	-2.8%	-2.1%
(production [million ton/yr])	(0.86)	(0.80)	(0.53)	(0.49)	(0.86)	(0.80)	(0.87)	(0.88)
Chemical	-3.7%	-11.2%	-35%	-40%	-3.3%	-10.7%	-2.1%	-1.7%
Non-metal materials	-2.1%	-2.7%	-30%	-34%	-1.7%	-3.8%	-0.9%	-0.6%
Non-ferrous metals	-1.4%	-2.7%	-35%	-39%	-1.2%	-5.0%	-0.8%	-0.2%
Paper and pulp	-3.5%	-6.3%	-33%	-37%	-3.1%	-7.2%	-1.5%	-1.7%
Transport machinery	-4.1%	-6.9%	-42%	-47%	-4.7%	-8.2%	-1.6%	-2.0%
GDP (excluding the overseas diffusion effects)	-4.1%	-5.6%	-13%	-14%	-3.6%	-5.9%	-1.8%	-2.1%
GDP/GNI (including the overseas diffusions particularly of mitigation technologies/products)	Approximately same of the potential economic growth (overseas effects:+4% to +5%)		Less expectation on the overseas additional effects of economic increase		Approximately same of the potential economic growth (overseas effects:+3% to +4%)		Approximately same of the potential economic growth (overseas effects:+1%)	
Annual growth in GDP/GNI since 2023 (including future population decrease)	+1.5%/yr	+1.2%/yr	+0.6%/yr	+0.7%/yr	+1.4%/yr	+1.2%/yr	+1.4%/yr	+1.2%/yr

In the Low Growth scenario where the relative energy price in Japan is high, estimated economic growth is low. In the High Growth scenario where the difference among relative energy prices is small, the negative impacts of emissions reduction countermeasures are relatively small and will achieve slightly higher economic growth than that of the Cabinet Office (1.4%/yr until 2040), thanks to the international advantages of mitigation technologies in Japan, while achieving carbon neutrality.

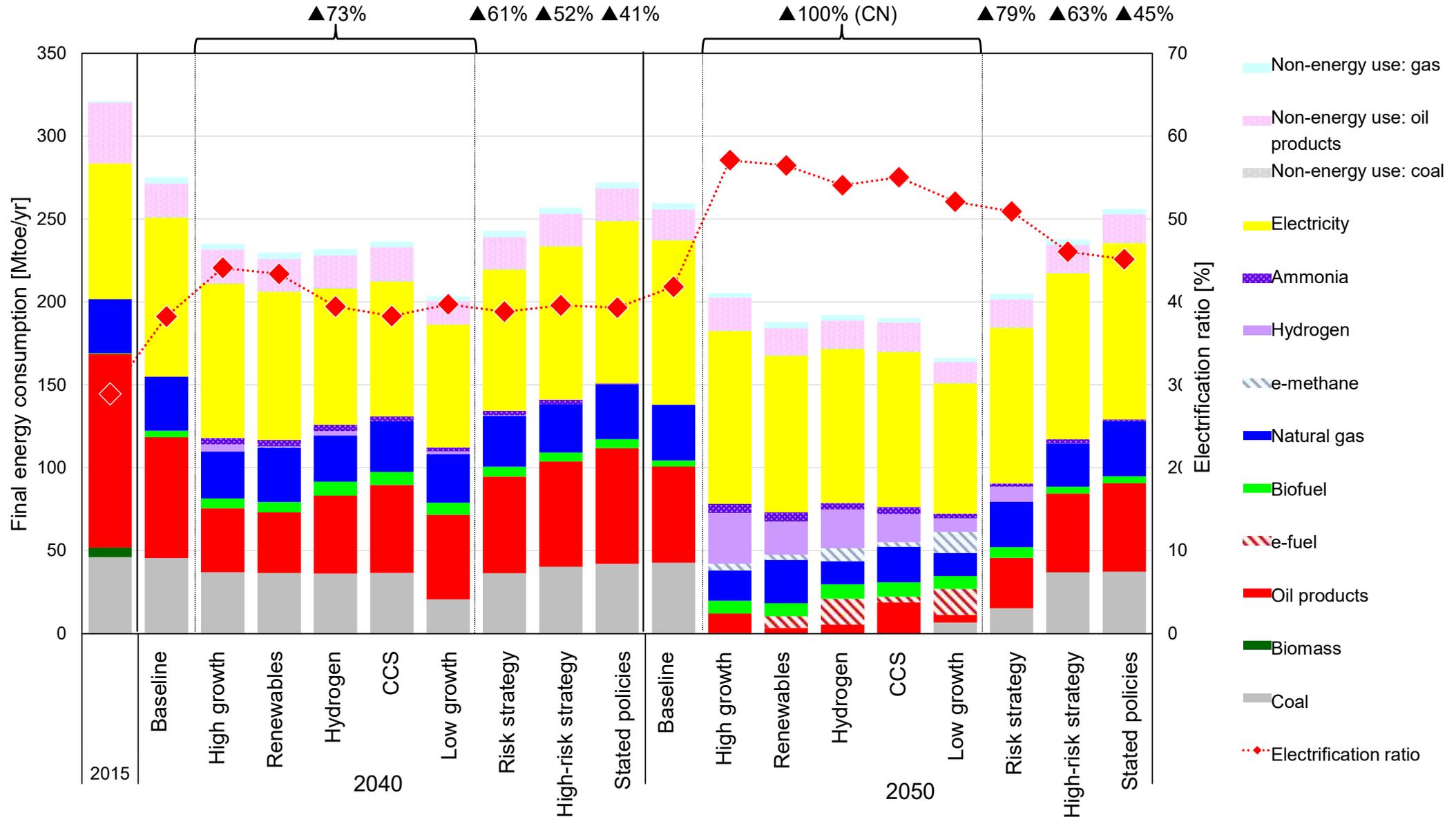
Primary Energy Supply in Japan

GHG emissions in Japan (vs 2013) [-23% in 2022]



Total Final Energy Consumption in Japan

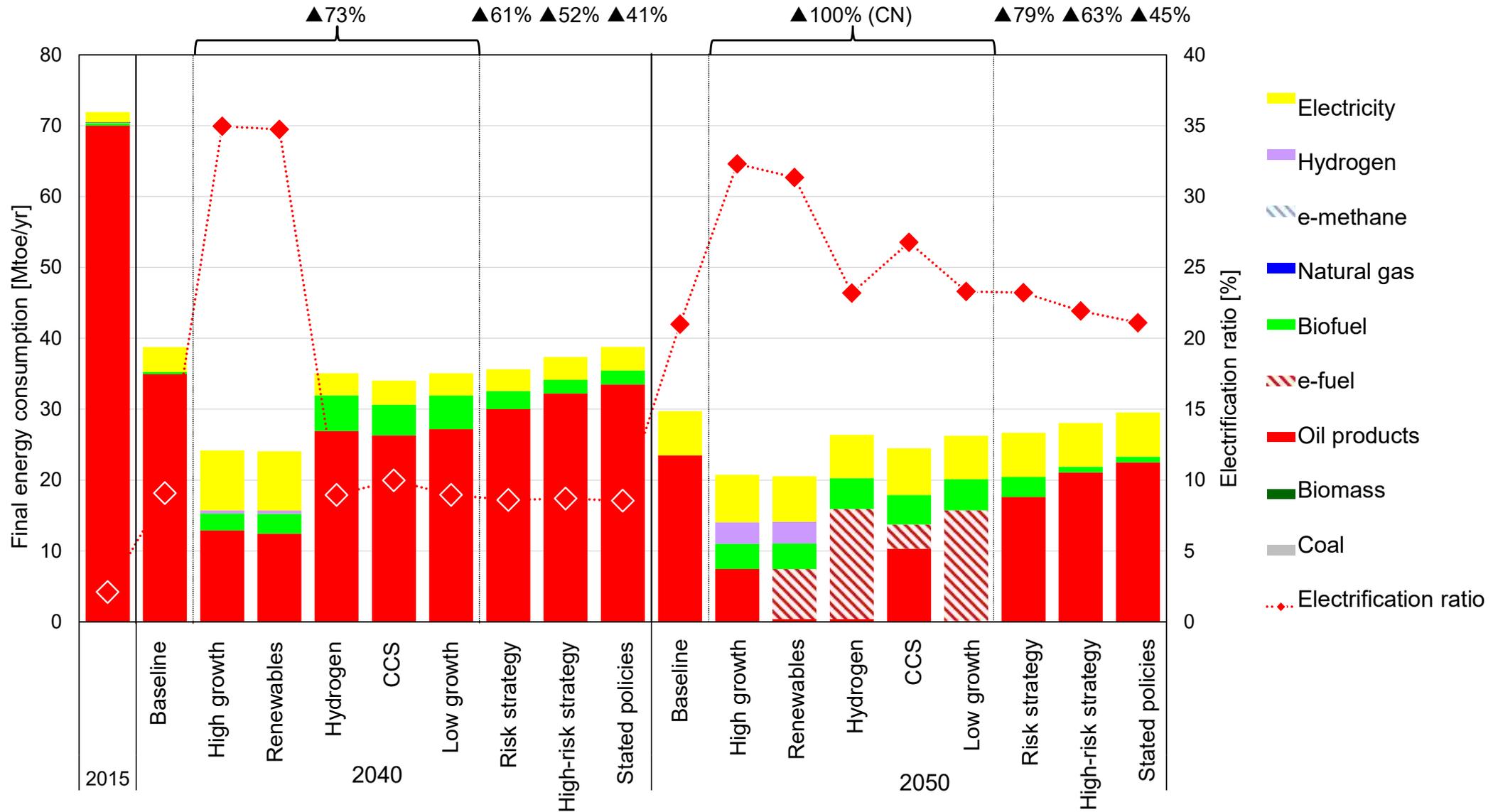
GHG emissions in Japan (vs 2013) [[-23% in 2022 (including LULUCF)]



- ✓ Electrification rates rise as emission constraints become stringent
- ✓ By 2050, uses of hydrogen, ammonia, e-methane, and e-fuels are significantly suppressed in the High-risk strategy and the Stated policies scenarios

Final energy consumption: Transport

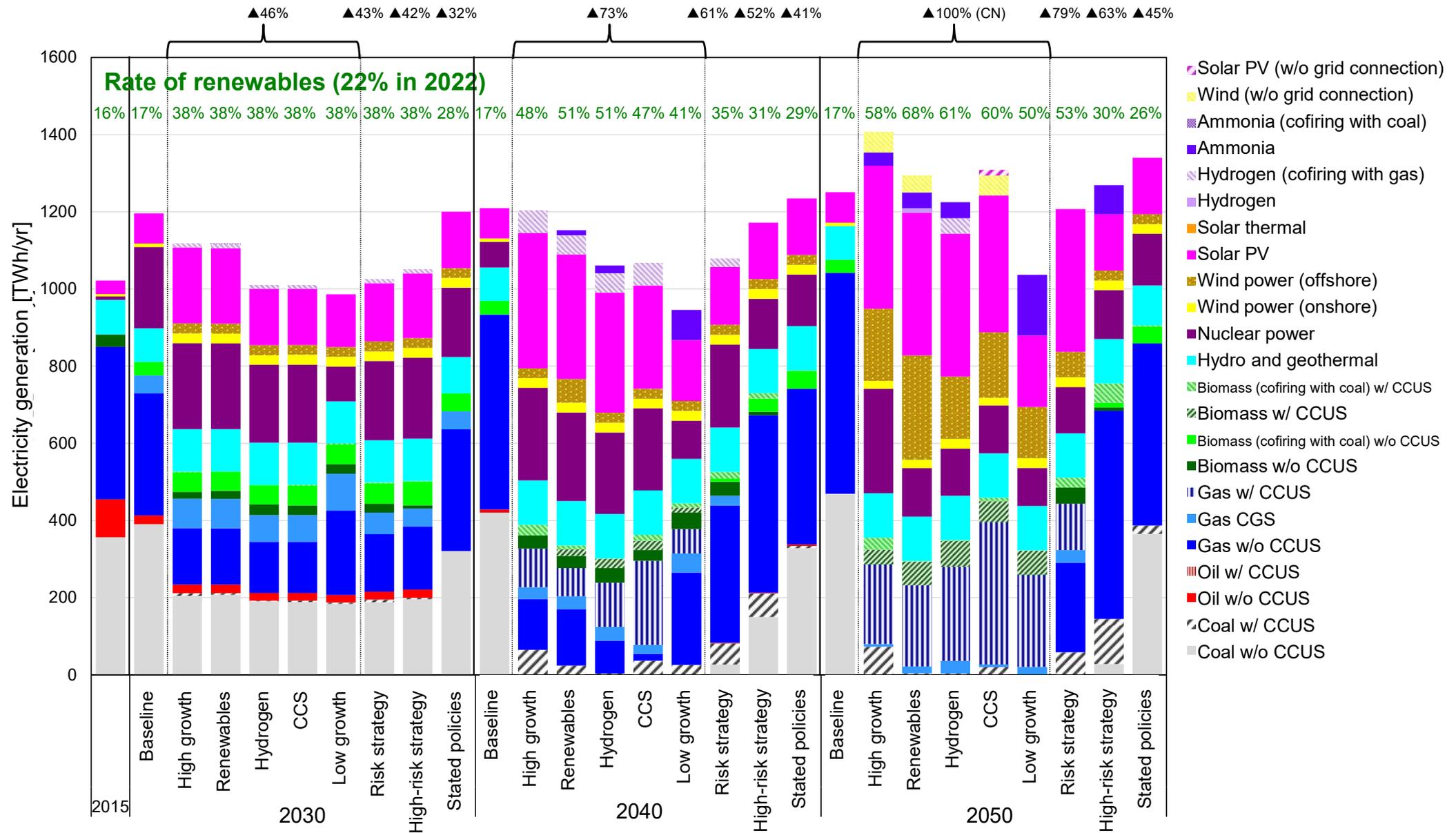
GHG emissions in Japan (vs 2013) [[-23% in 2022 (including LULUCF)]]



✓ As scenario transitions from “Risk” to “High-risk” or “Stated policies”, biofuel consumption and energy saving decrease, and oil consumption increases.

Electricity supply in Japan

GHG emissions in Japan (vs 2013) [[-23% in 2022 (including LULUCF)]



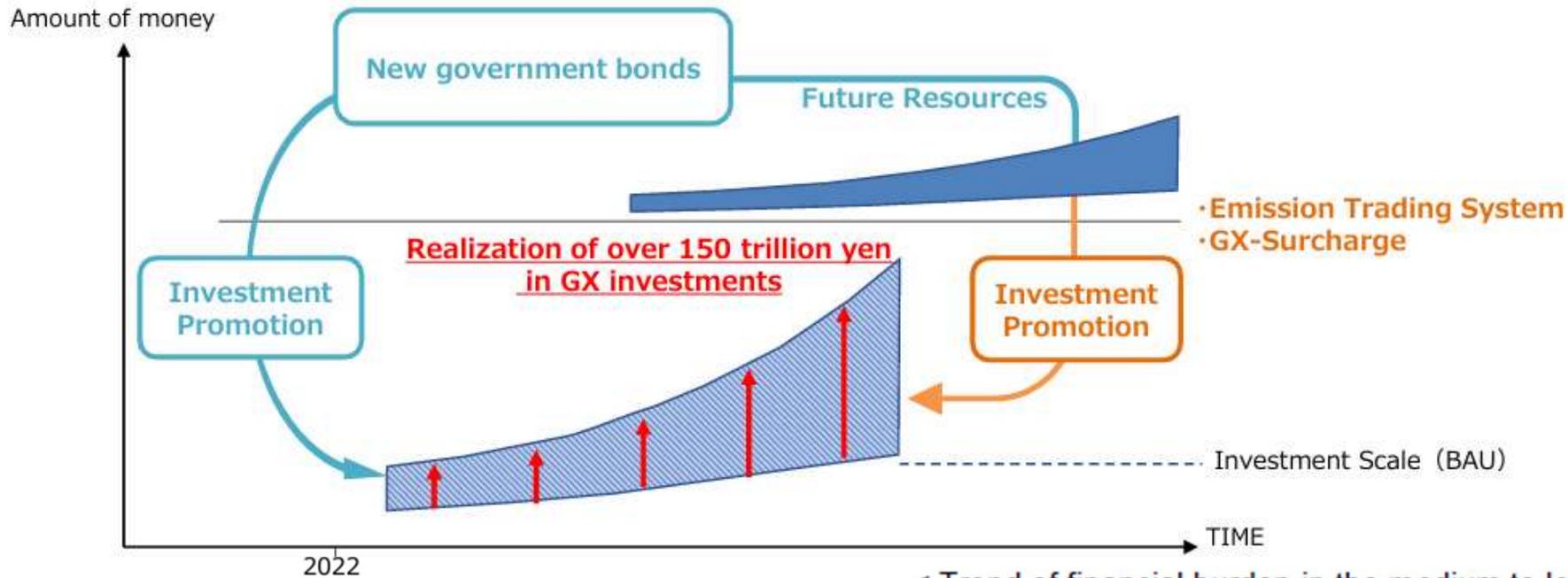
✓ In the High-risk strategy scenario, LNG-CC without CCS is dominant even in 2050

✓ In the Stated policies scenario, coal without CCS is economical even in 2050

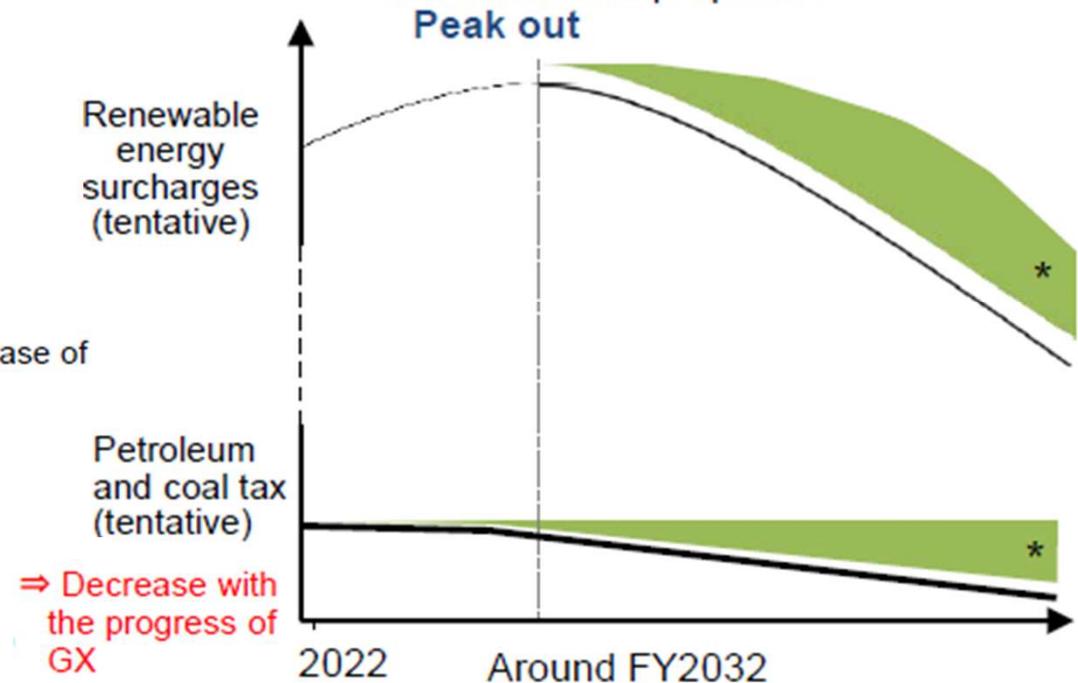
4. Carbon price policies: challenges and outlook



Relationship between subsidies by GX Economy Transition Bonds and their burden



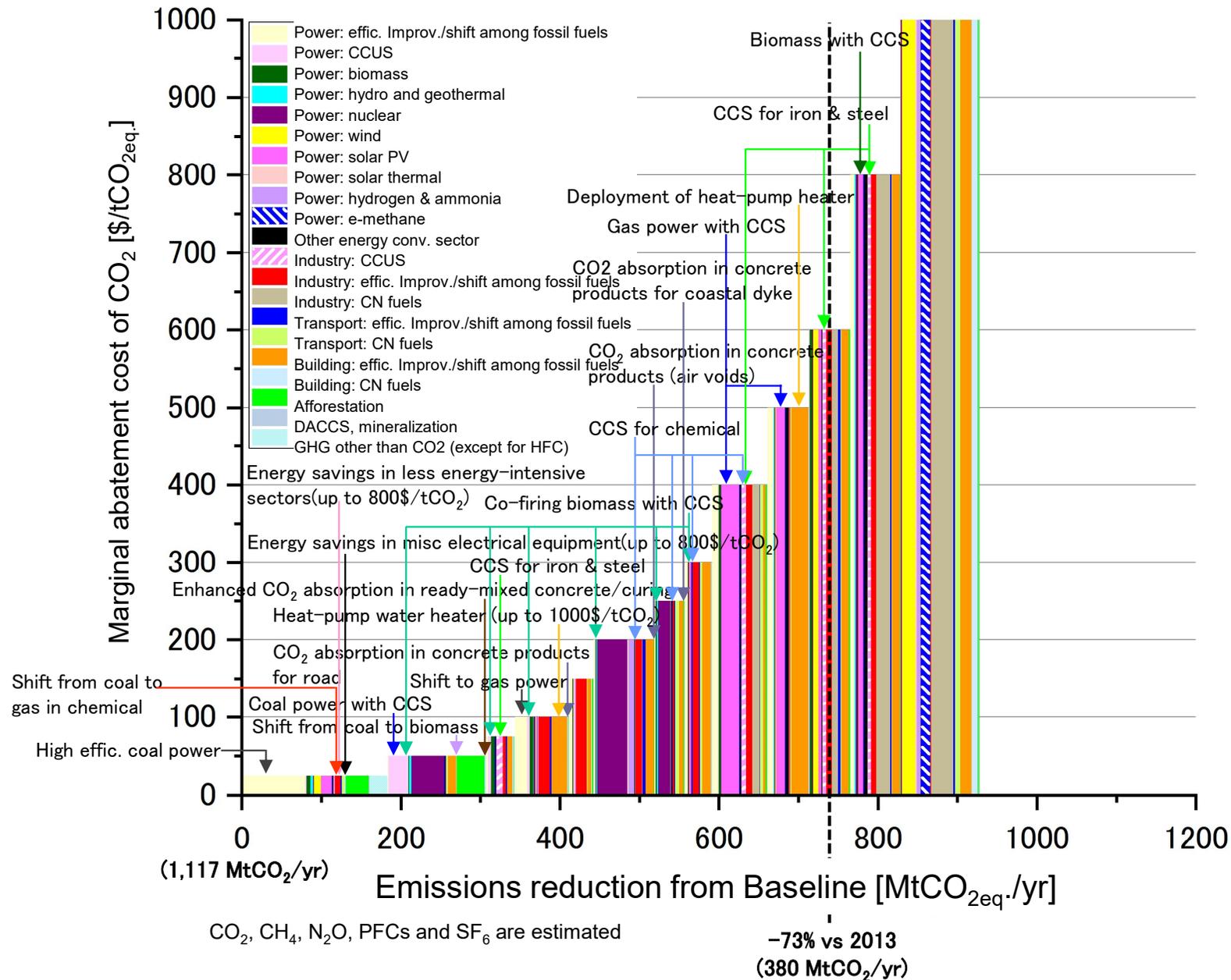
< Trend of financial burden in the medium to long term >
(for illustrative purposes)



- Introducing the following within the extent of the future decrease of energy-related financial burden
 - Requiring electricity generation utilities to pay for emissions quotas (starting from FY2033)
 - Carbon surcharges (starting from FY2028)

Potentials and costs of emissions reduction by sector and technology in Japan, 2040

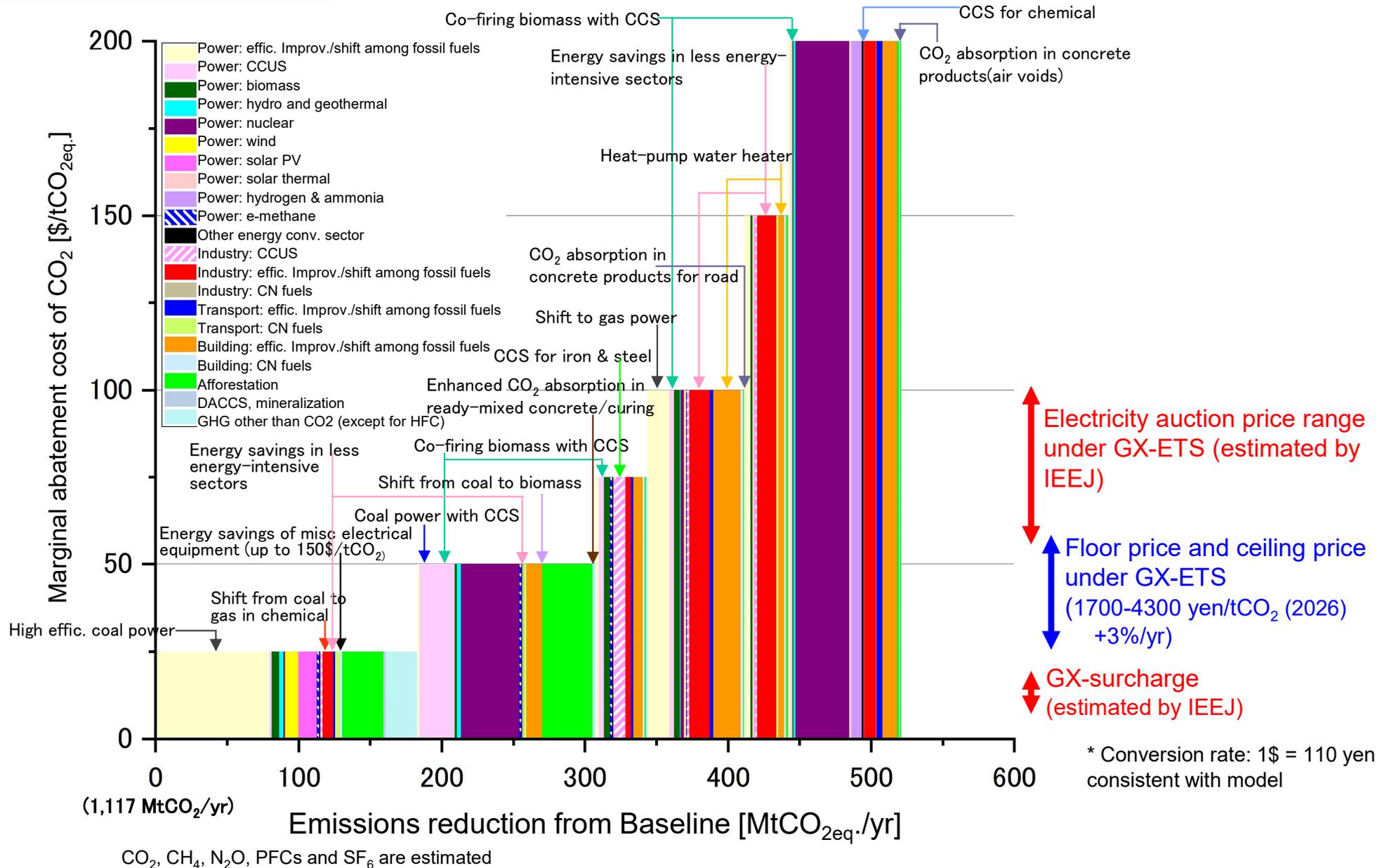
- Risk strategy scenario -



Note: Scales of reductions by sector and technology may vary depending on the sectors or technologies in the interaction terms, or on definitions of technology allocation. Estimated reduction potentials should therefore be taken as approximations

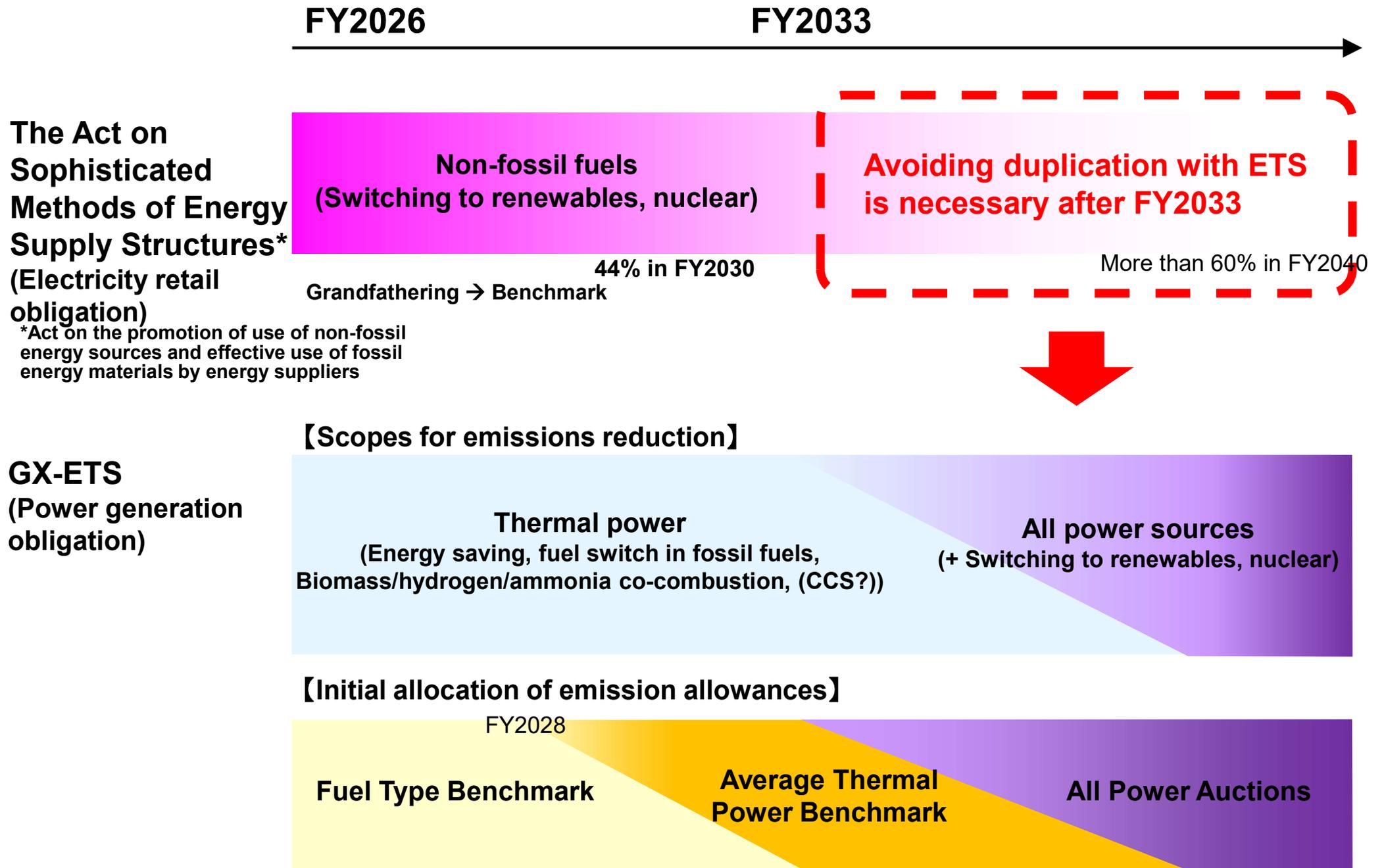
Potentials and costs of emissions reduction by sector and technology in Japan, 2040

- Risk strategy scenario - <200\$/tCO₂



Note: Scales of reductions by sector and technology may vary depending on the sectors or technologies in the interaction terms, or on definitions of technology allocation. Estimated reduction potentials should therefore be taken as approximations

Overlapping policy issue: Obligation accomplished market and GX-ETS



Adjustment of carbon price level between GX-ETS and other systems

GX-ETS ceiling/floor prices

	FY2026	~FY2030
Floor price	1700JPY /tCO ₂	+3%/yr + price fluctuation
Ceiling price	4300JPY/tCO ₂	

Obligation accomplished market

	Non-FIT certificate (JPY/kWh)	Carbon price (JPY /tCO ₂)	
		Coal substitute	LNG combined cycle substitute
Lowest	0.6	692	1596
Highest	1.3	1499	3457

Renewable energy feed in tariff (FIT)

	Procurement price (JPY/kWh)	Carbon price (JPY/tCO ₂)	
		Coal substitute	LNG combined cycle substitute
Residential PV	15	5767	13298
On-shore wind	12	2307	5319
General wood (less than 10,000kW)	24	16148	37234
Methane fermentation	39	33449	77128
Geothermal (more than 15,000kW)	26	18454	42553

- ✓ Adjustment of carbon price level between GX-ETS and obligation accomplished market is important, even before 2033, when all power sources are in scope afterward.
- ✓ Furthermore, coordination among related systems, including FIT, is also important for effective emissions reduction.



5. Conclusion



- ◆ In February 2025, the Cabinet Decision was made on the Seventh Strategic Energy Plan, Global Warming Countermeasures, and GX2040 vision. GoJ also resolved -63% by 2035 and -70% by 2040 (vs 2013) as the NDC of Japan.
- ◆ Emissions reduction in Japan is often explained as “on track towards CN by 2050”, but decreases in industrial activity or overseas relocation of industry are contributing to this significantly, which is common to advanced.
- ◆ Nations have submitted NDCs for 2035, which are presumably developed with recognizing the gaps between the needs for their ambitious targets and difficulties in actual reductions.
- ◆ Significant differences among countries’ MACs in 2035 NDCs are estimated, which raise concerns about industrial leakage. In addition, countries that submitted high-level but infeasible targets have been observed more than ever.
- ◆ To explore policies that are effective for global climate mitigation while avoiding risks for industrial leakage, RITE conducted analyses of economically rational countermeasures under scenarios with carbon prices being lower than assumptions in the Strategic Energy Plan.
- ◆ GX-ETS, a mandatory carbon price policy, is to be introduced in 2026, and levies on carbon are imposed in 2028. Redesigning various schemes, such as avoiding duplication or coordination, is important to promote effective measures.
- ◆ As international coordination is becoming more difficult, effective and functioning coordination needs to be sought.