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The Status and Role of CCS in Japan

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1. Overview of Technological Measures for Carbon Neutrality

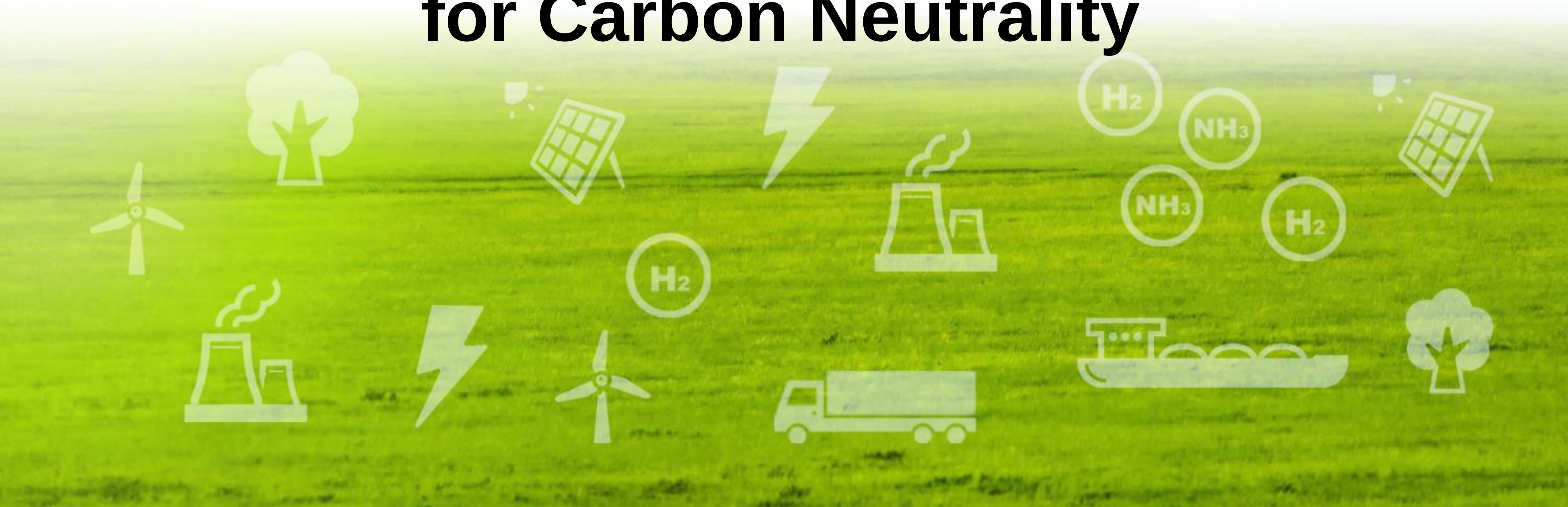
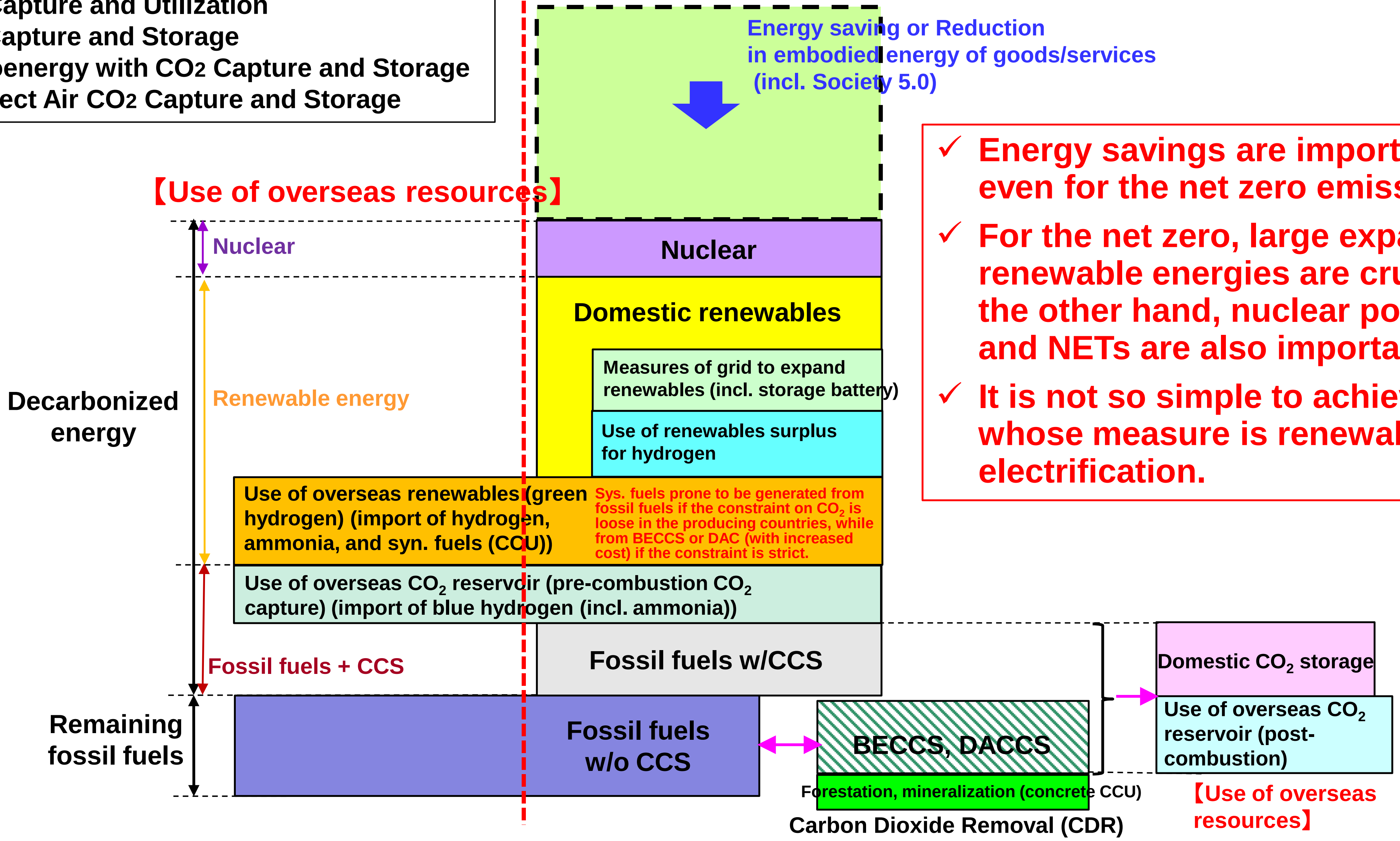


Image of Primary Energy for Carbon Neutrality (Net Zero Emissions)

CCU: CO2 Capture and Utilization
CCS: CO2 Capture and Storage
BECCS: Bioenergy with CO2 Capture and Storage
DACCS: Direct Air CO2 Capture and Storage

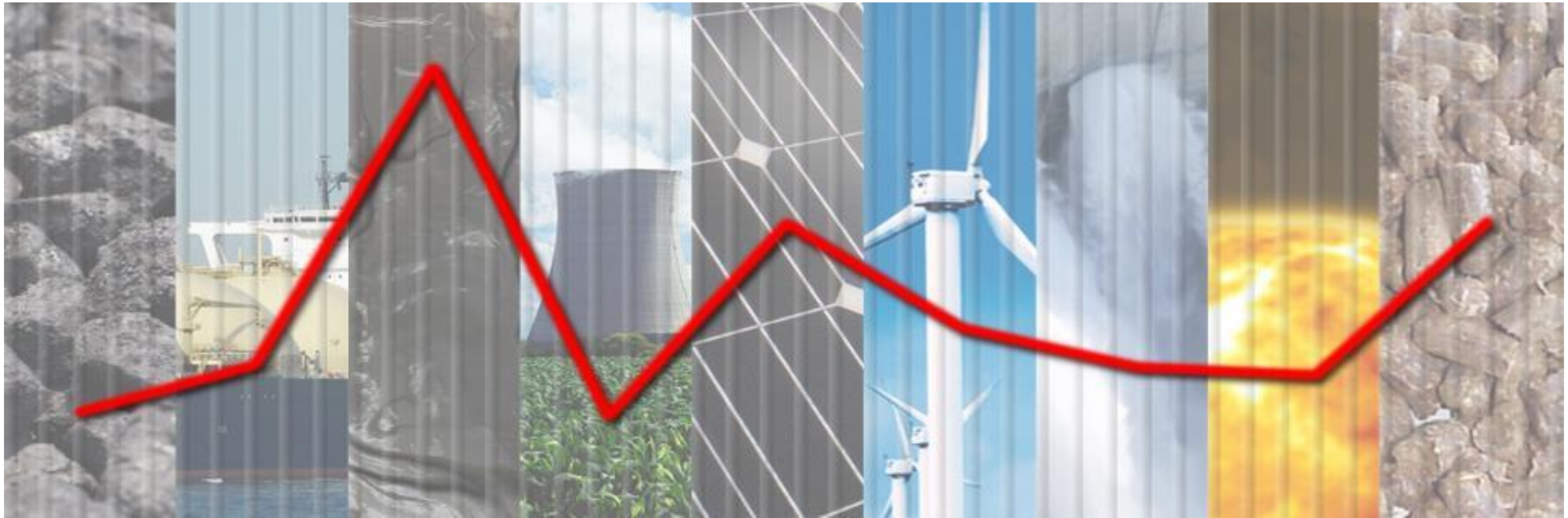


- ✓ Energy savings are important options even for the net zero emissions.
- ✓ For the net zero, large expansions of renewable energies are crucial. On the other hand, nuclear power, CCS, and NETs are also important options.
- ✓ It is not so simple to achieve net zero whose measure is renewables + electrification.

2. Economic Potentials of CCS toward Net-Zero Emissions in Japan

RITE Transition Roadmap to Carbon Neutrality: 2023 Edition

https://www.rite.or.jp/system/en/latestanalysis/2024/03/transition_roadmap_to_carbon_neutrality_2023_edition.html



Energy Assessment Model: DNE21+ (Dynamic New Earth 21+)

- Systemic cost evaluation on energy and CO_2 reduction technologies is possible.
- Linear programming model (minimizing world energy system cost; with 10mil. decision 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, CO_2 (provided that external transfer of CO_2 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-CO_2 GHG possible with another model RITE has developed based on US EPA's assumptions.**

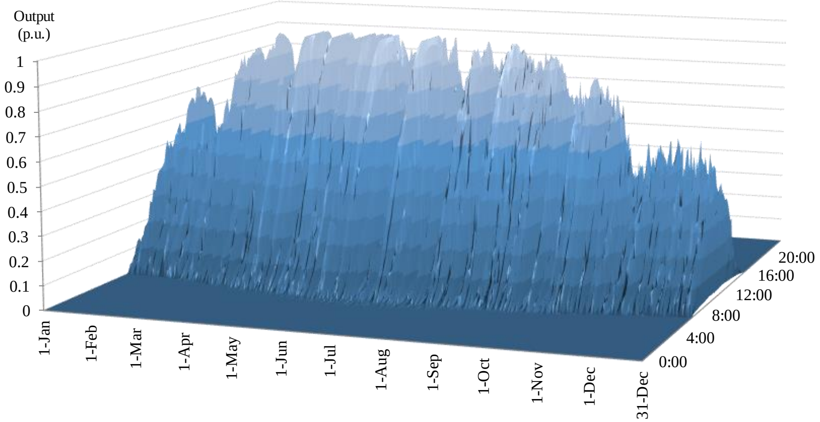
- **Model based analyses and evaluation provide recommendation for major governmental policy making on climate change, e.g., cap-and-trade system and Environmental Energy Technology Innovation Plan, and also contribute to IPCC scenario analysis.**

Integration Cost of VRES: integration with a Power Generation Mix Model by Univ. of Tokyo and IEEJ

- As DNE21+ is a global model and not suitable for the analysis regarding internal power grid and regional conditions of renewable energy, it applies the results of the study on the assumption of integration cost under high VRE penetration based on an optimal power generation mix model, by Fujii-Komiyama Laboratory, the University of Tokyo and the Institute of Energy Economics, Japan.
- Time fluctuation of VRE output is modeled based on nationwide meteorological data, e.g., AMeDAS, to estimate the optimal configuration (power generation and storage system) and the annual operation by linear programming.
- Calculated with hourly modeling by 5 divided regions (Hokkaido, Tohoku, Tokyo, Kyushu and others). Prerequisites for power generation cost, resource constraint, etc, are defined in line with DNE21+.

Considered in modeling･･･ Output control, power storage system (pumped hydro, lithium-ion battery and hydrogen storage), reduction of power generation facility utilization, inter-regional power transmission lines, electricity loss in storage and transmission

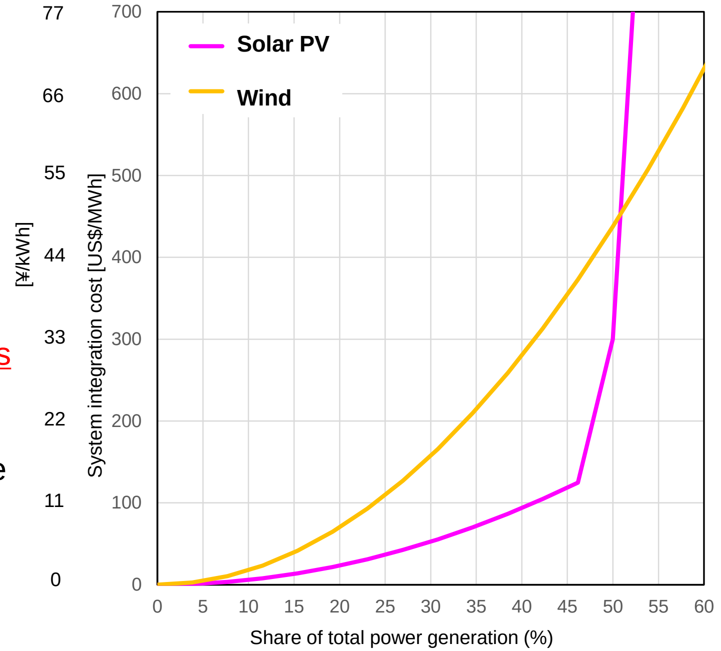
Not considered in modeling･･･ Intra-regional power transmission lines, power grid, influence of decrease of rotational inertia, grid power storage by EV, prediction error of VRE output, supply disruption risk during dark doldrums



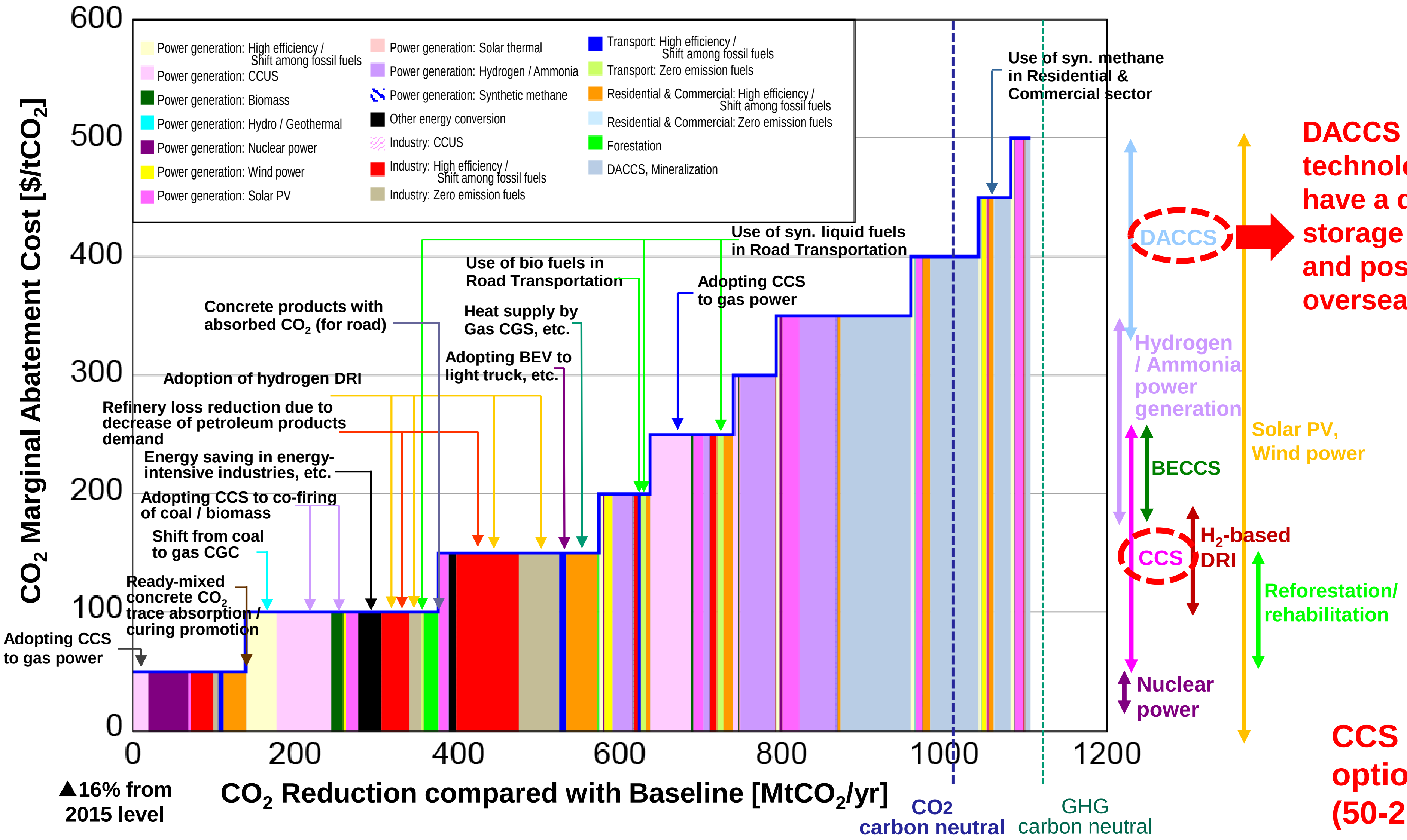
Output example of PV

As the VRE ratio increases, marginal integration costs tend to rise relatively rapidly. This is because under the circumstance where a large amount of VRE has already been installed, if it is further installed, it will be required to maintain an infrequently used power storage system or transmission line to deal with the risk that cloudy weather and windless conditions will continue for several days or more.

Grid integration costs approximated from the analysis of the Univ. of Tokyo – IEEJ power generation mix model＝Assumption on grid integration costs in DNE21+ (Marginal cost when each implementation share is realized)



Emission reduction potentials and costs in 2050 by sector and technology: Japan



DACCS will serve as a "backstop" technology even in Japan, but will have a dependency on CO2 storage potentials domestically and possibilities of transport to overseas.

CCS is a relatively cheap option also in Japan (50-250 USD/tCO2 in 2050).

Note 1) This analysis shows the result of the estimation under the technology assumption in the "Reference case".

Note 2) The emission reduction potentials in this analysis should be referenced as a rough guide, as the emission reduction effects by sector / technology will vary depending on the definition of the variables for sectors, countermeasures, and technologies, etc.

Assumed scenarios for the 2 °C and 1.5 °C goals

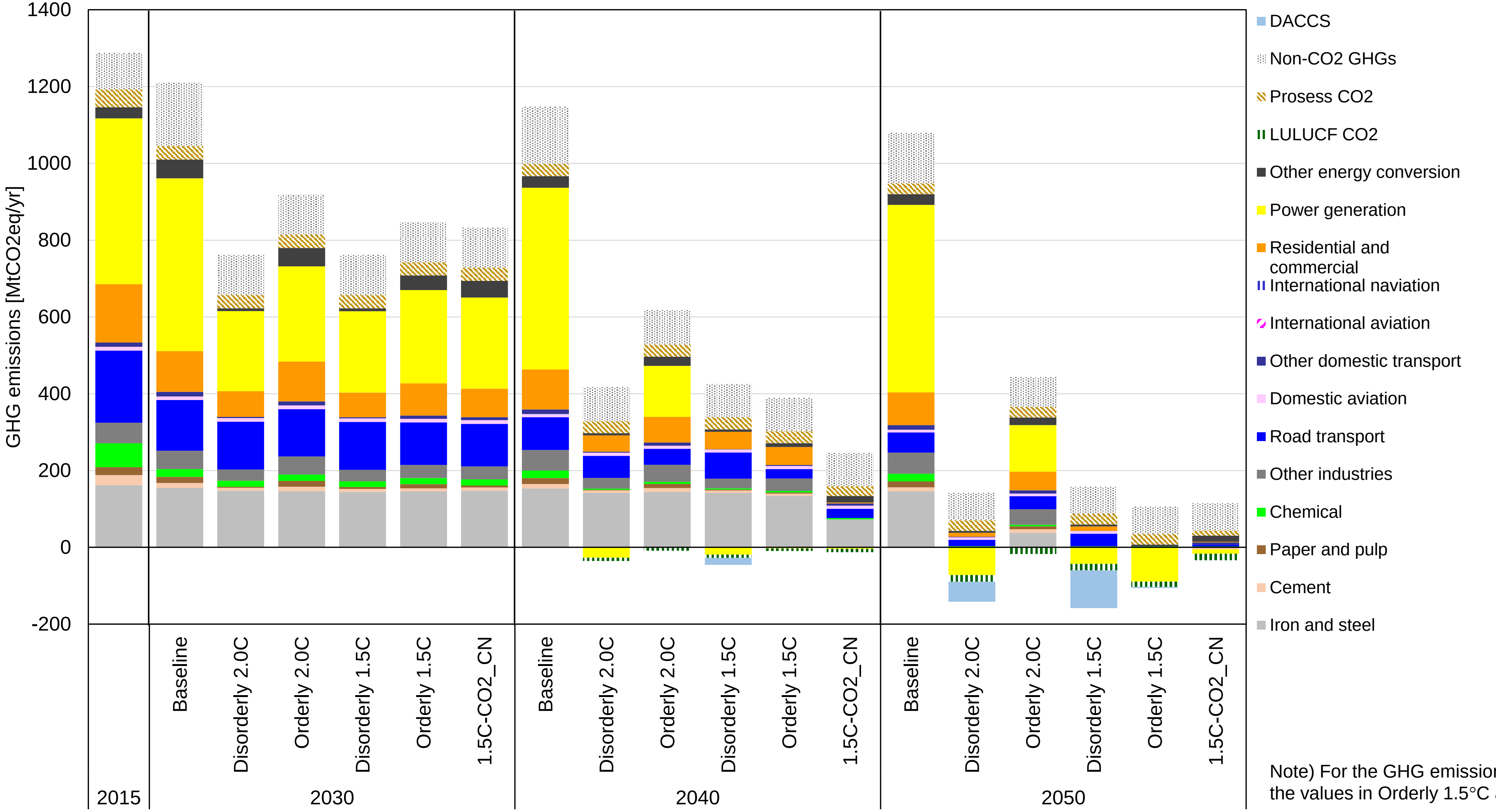
Scenarios	Global average temp. increase	Policy implementation speed#	CDR contribution	Renewables and BEV	Differences in policy intensity among regions	Corresponding scenarios		
						IPCC AR6 (IPCC 2022)	NGFS (2022)	IEA
Disorderly Below 2 °C	1.7 °C in 2100 (peak:1.8 °C)	Gradual (NDCs in 2030)	medium	Medium cost reductions	Large (major developed countries: CN by 2050)	Likely below 2 C, NDC [C3b]	Disorderly: Delayed Transition	APS (WEO 2022)
Orderly Below 2 °C	1.7 °C	Rapid	Small	High cost reductions	Small (equal MAC among countries)	Likely below 2 C with immediate action [C3a]	Orderly: Below 2C	SDS (WEO 2021)
Disorderly 1.5 °C	1.4 °C in 2100 (peak:1.7 °C)	Gradual (NDCs in 2030)	Large	Medium cost reductions	Large (major developed countries: CN by 2050)	1.5 C with high overshoot (IMP-Neg) [C2]	(Disorderly: Divergent Net Zero)*	
Orderly 1.5 °C	1.4 °C in 2100 (peak:1.6 °C)	Rapid	Medium	High cost reductions	Medium (major developed countries: CN by 2050)	1.5 C with no or limited overshoot [C1]	Orderly: Net Zero2050	
1.5C-CO2_CN	Approx. below 1.5 °C	Rapid	Small (Near-zero of CO2 by sector)	High cost reductions	Large (major developed countries: CN by 2050)	1.5 C with no or limited overshoot [C1]		NZE

The emission reduction targets in 2030 of NDCs submitted in the end of December 2021 are considered.

* The emissions pathway is rather similar to the Orderly 1.5 °C

- ✓ **The assumed scenarios are consistent with the long-term goals of Paris Agreement, and cover the existing scenarios which are widely referred globally.**
- ✓ **The scenarios also cover a certain range of uncertainties in technologies and policies.**

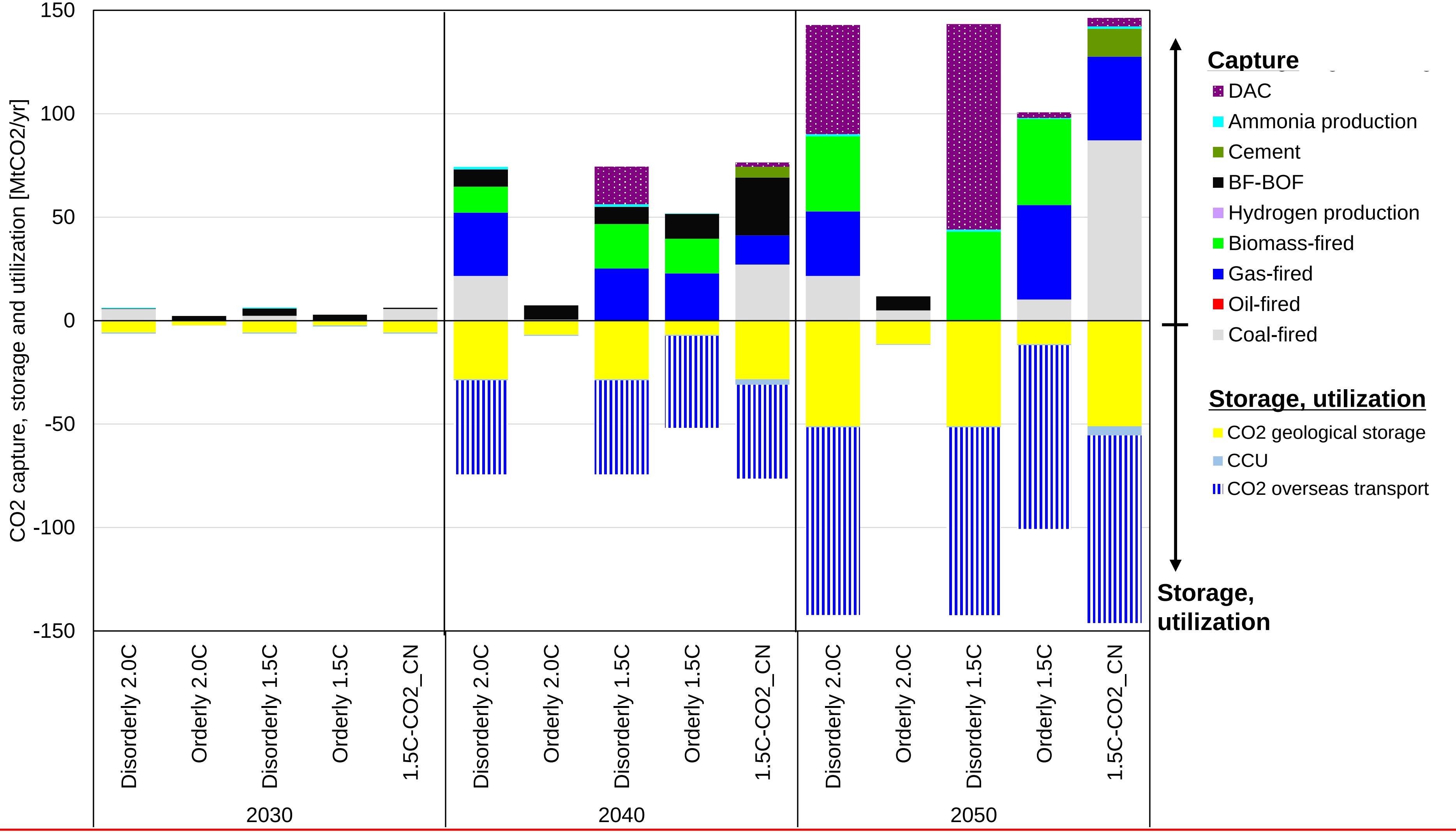
GHG emissions (Japan)



Note) For the GHG emissions other than CO2 in 1.5C-CO2_CN, the values in Orderly 1.5°C are shown here.

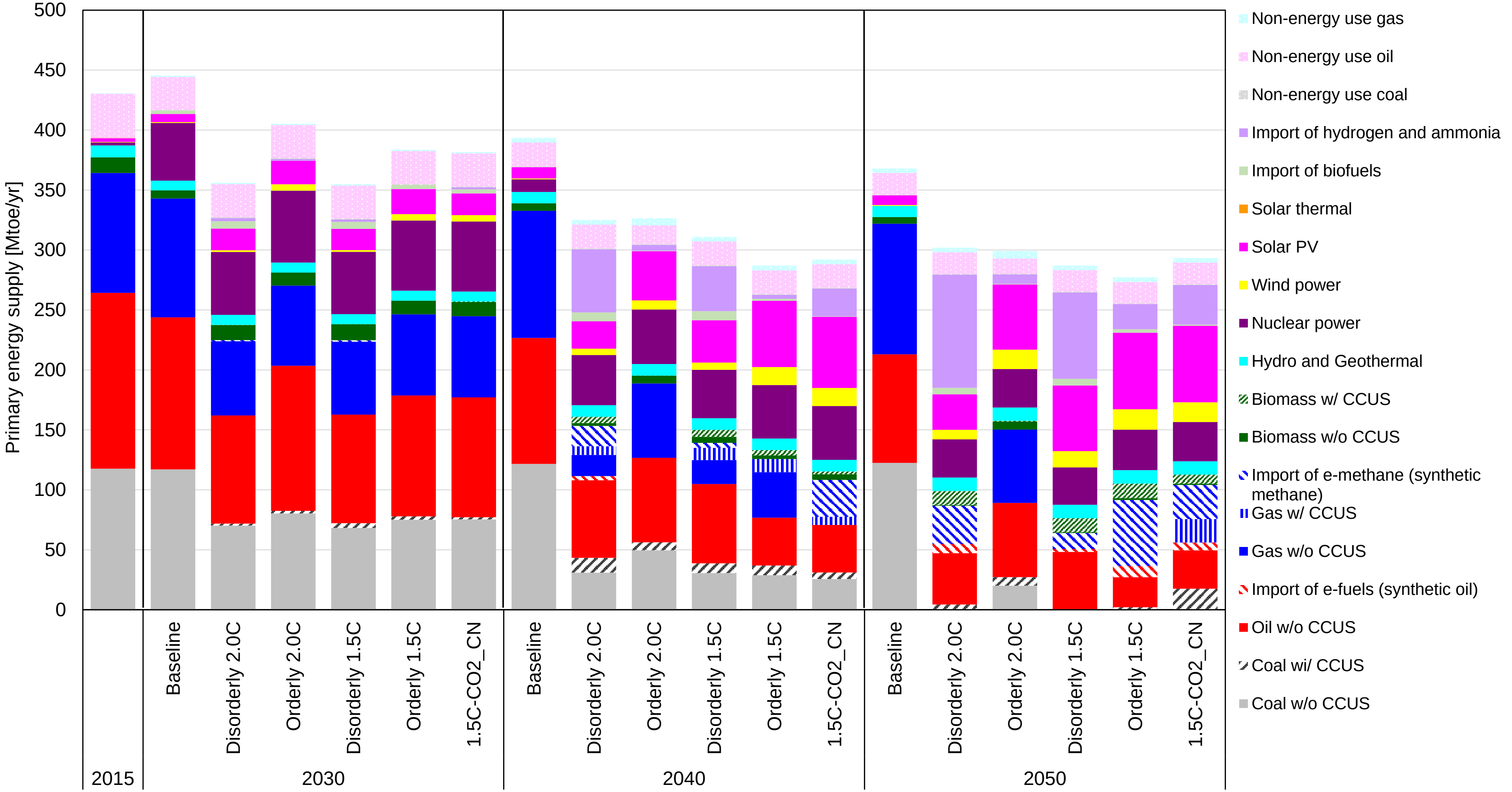
- ✓ **To achieve CN in GHG emissions in 2050, DACCS, the use of LULUCF CO_2 (fixation by forestation), and the measures for net negative CO_2 emissions in the Power sector, such as BECCS and e-methane+CCS, will be applied.**
- ✓ **In Orderly 2.0°C where CN in GHG emissions in 2050 is not assumed, the total GHG emissions will be approximately ▲69% relative to 2013, with positive CO_2 emissions from the Power sector and the Iron and steel sector.**

CO_2 balance (Japan)



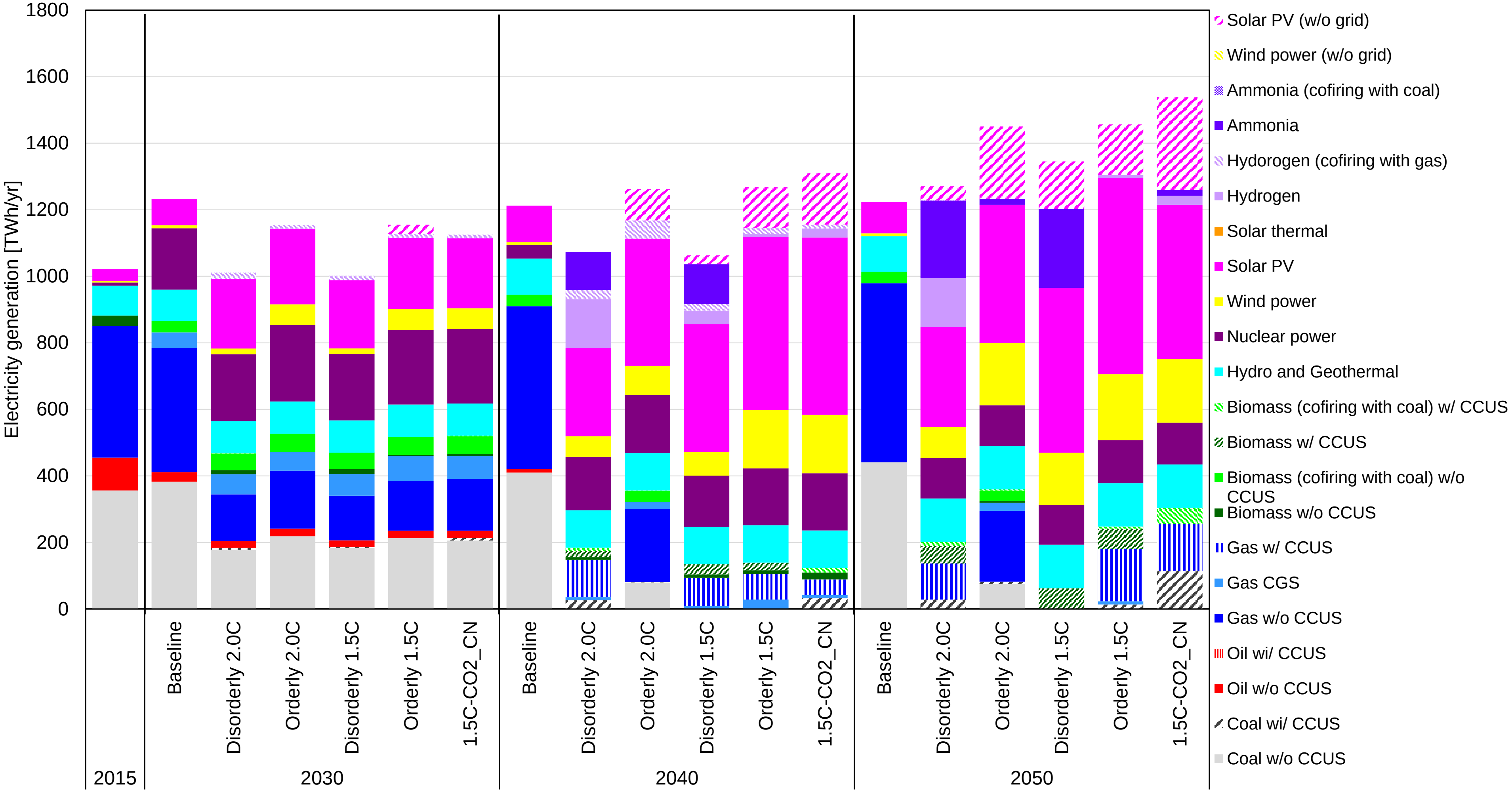
- ✓ CO_2 capture through fossil-fired power generation and BF process (Super COURSE50) are observed in 2040.
- ✓ CO_2 capture through DAC and Biomass processes will be large in 2050.
- ✓ Under 1.5C-CO_2_CN, with limited CDR uses including BECCS and e-methane+CCS in the Power sector, CO_2 is captured from coal-fired (incl. Biomass co-firing) and gas-fired, and in the Cement sector in 2050. Captured CO_2 via DAC is used for CCU.

Primary energy supply (Japan)



- ✓ **Import of hydrogen and ammonia, e-methane, and biofuels would be cost-effective as the MAC of Japan is higher than other countries. However, those amounts in Orderly 2.0°C are relatively small (approx. ▲69% relative to 2013 in 2050).**
- ✓ **Coal use incl. with CCUS is scarcely observed in the scenarios of GHG CN in 2050. However, in Orderly 2.0°C, some coal w/o CCUS and a reasonable amount of gas w/o CCUS are likely to remain.**
- ✓ **Import of hydrogen and ammonia, e-methane, and biofuels would be cost-effective as well in 1.5C -CO_2_CN.**

Electricity supply (Japan)



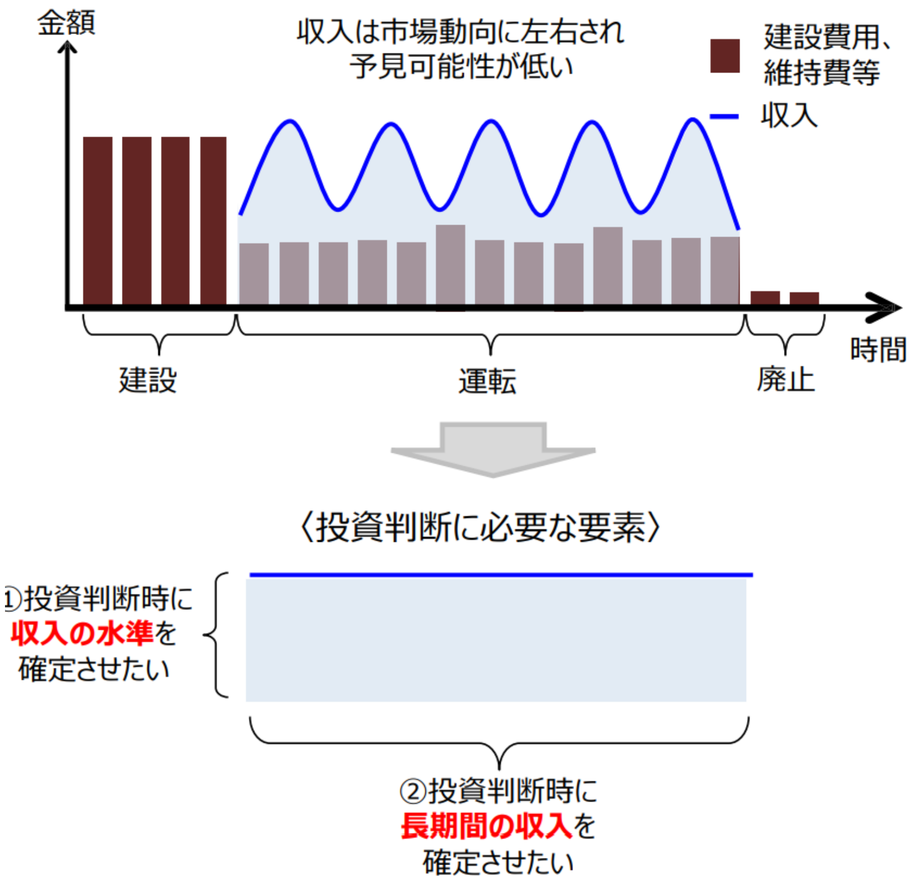
- ✓ **Electricity supply is in an upward trend, especially in the strict emissions reduction scenarios.**
- ✓ **The deployment of renewable energy, such as solar PV, the use of CCS, and power generation with imported hydrogen and ammonia are observed. Also, e-methane is used for gas power generation in 2050 in the scenarios other than Orderly 2.0°C.**
- ✓ **Solar PV and wind power are likely to diffuse further due to high cost reduction in Orderly 1.5°C.**
- ✓ **In 1.5C-CO_2_CN, a portion of coal with CCUS increases due to the constraint of BECCS and e-methane+CCS.**

3. Policy Status in Japan

Long-term commitment to revenues for new decarbonized power through capacity market in power sector (1/2)

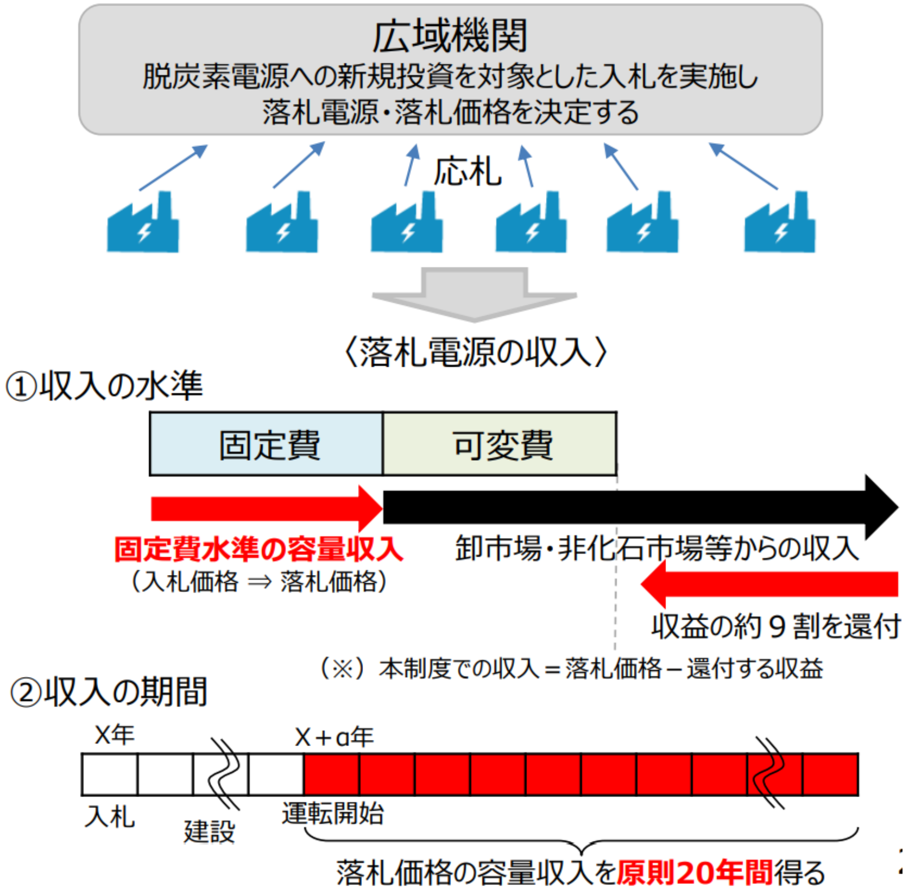
Issues for investment

〈電源投資の課題〉



New scheme

〈新制度のイメージ〉



- ✓ **In the capacity market, the revenues for providing kW are uncertain in the future, and there can be large risks of investing in decarbonized power plants (including CCS) which are higher unit costs of kW in general.**
- ✓ **A new scheme for new decarbonized power which commit the revenues for 20 years has been introduced from FY2023. Then, a certain part of the investment risks will be reduced.**

Long-term commitment to revenues for new decarbonized power through capacity market in power sector (2/2)

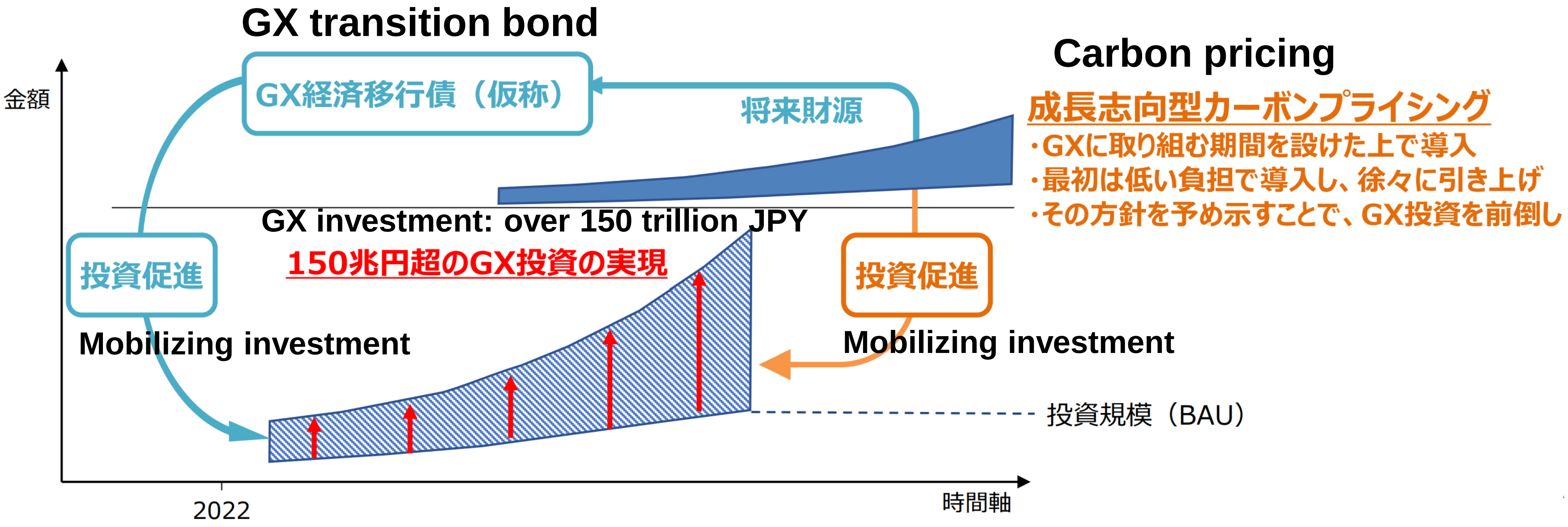
Consideration in different lead time

Deadline for power supply

電源種		供給力提供開始期限（案）
太陽光	Solar PV	5年（法・条例アセス済の場合：3年）
風力、地熱	Wind, geothermal	8年（法・条例アセス済の場合：4年）
水力	Hydro power	12年（法・条例アセス済の場合：8年） （多目的ダム併設型についてはダム建設の遅れを考慮）
水素・アンモニア（専焼）、バイオマス 水素・アンモニア混焼のLNG、CCS火力 既設火力の改修（水素・アンモニア混焼、バイオマス専焼）	Hydrogen, ammonia, biomass, LNG with hydrogen/ammonia, CCS	11年（法・条例アセス済・不要の場合：7年）
原子力	Nuclear	17年（法・条例アセス済の場合：12年）
蓄電池	Battery	4年
LNG（時限的に対象）	LNG (only for limited years)	6年 ※21頁のとおり、早期に供給力を提供開始できる新設・リプレース案件のみを対象とするため、供給力提供開始期限を短く設定

✓ **Construction times are different among power sources. Different lead times among power sources are considered in the new capacity market for long-term decarbonized power.**

GX transition bond and carbon price (under discussions)



１３	CCS	約4兆円～	**CCS事業法の整備** • 2030年までのCCS事業開始に向けた事業環境を整備するため、模範となる先進性のあるプロジェクトの開発及び操業を支援するとともに、早急にCCS事業法（仮称）を整備する。

✓ Introduction of emissions trading schemes in the future (for just image, ETS with free allocation from around 2025, and with auction from around 2028), and subsidy schemes through “GX transition bond” of over 150 trillion JPY based on the auction revenues in the future.

the Act on Carbon Dioxide Storage Businesses (enacted in May, 2024)

背景・法律の概要

- ✓ **2050年カーボンニュートラル**に向けて、今後、脱炭素化が難しい分野におけるGXを実現することが課題。こうした分野における**化石燃料・原料の利用後の脱炭素化を進める手段**として、CO2を回収して地下に貯留する**CCS**（Carbon dioxide Capture and Storage）**の導入が不可欠**。
- ✓ **我が国としては、2030年までに民間事業者がCCS事業を開始するための事業環境を整備**することとしており（GX推進戦略　2023年7月閣議決定）、公共の安全を維持し、海洋環境の保全を図りつつ、その事業環境を整備するために必要な**貯留事業等の許可制度等を整備**する。

1．試掘・貯留事業の許可制度の創設、貯留事業に係る事業規制・保安規制の整備

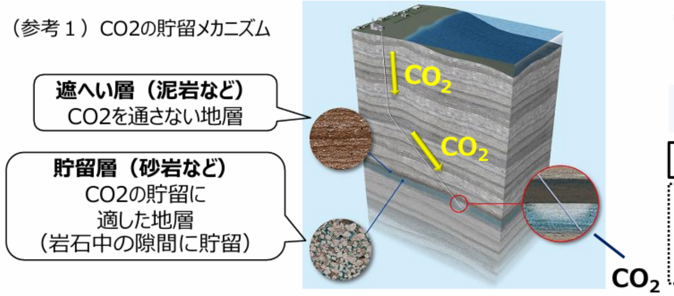
（1）試掘・貯留事業の許可制度の創設

- **経済産業大臣は**、貯留層が存在する可能性がある区域を「**特定区域**」として**指定**※した上で、特定区域において**試掘やCO2の貯留事業**を行う者を**募集**し、これらを**最も適切に行うことができると認められる者**に対して、**許可**※を与える。

※　海域における特定区域の指定及び貯留事業の許可に当たっては環境大臣に協議し、その同意を得ることとする。

- 上記の許可を受けた者に、**試掘権**（貯留層に該当するかどうかを確認するために地層を掘削する権利）や**貯留権**（貯留層にCO2を貯留する権利）を**設定**する。CO2の安定的な貯留を確保するための、**試掘権・貯留権は「みなし物権」**とする。
- **鉱業法に基づく採掘権者**は、上記の**特定区域以外の区域（鉱区）**でも、経済産業大臣の許可を受けて、**試掘や貯留事業を行うことを可能とする**。

（参考１）CO2の貯留メカニズム



（出典）日本CCS調査（株）資料（資源エネルギー庁にて一部加工）

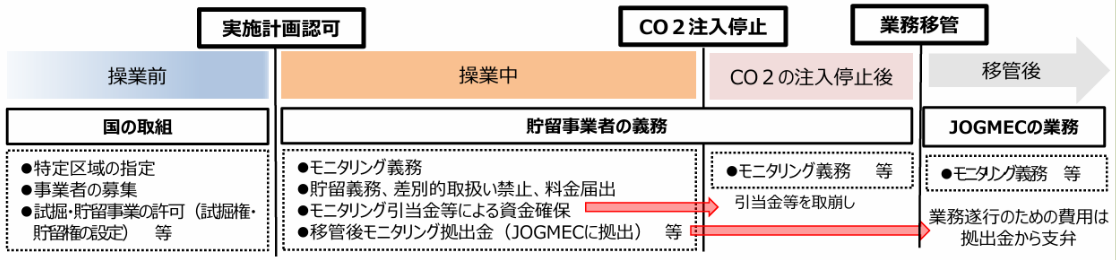
（2）貯留事業者に対する規制

- **試掘や貯留事業の具体的な「実施計画」**は、**経済産業大臣（※）の認可制**とする。

※　海域における貯留事業の場合は、経済産業大臣及び環境大臣

- 貯蔵したCO2の漏えいの有無等を確認するため、**貯留層の温度・圧力等のモニタリング義務**を課す。
- **CO2の注入停止後に行うモニタリング業務等に必要な資金**を確保するため、**引当金の積立て等**を義務付ける。
- 貯留した**CO2の挙動が安定**しているなどの要件を満たす場合には、**モニタリング等の貯留事業場の管理業務をJOGMEC**（独法エネルギー・金属鉱物資源機構）**に移管**することを可能とする。また、**移管後のJOGMECの業務に必要な資金**を確保するため、貯留事業者に対して**拠出金の納付**を義務付ける。
- 正当な理由なく、**CO2排出者からの貯留依頼を拒むこと**や、**特定のCO2排出者を差別的に取扱うこと**等を禁止するとともに、**料金等の届出義務**を課す。
- **技術基準適合義務**、**工事計画届出**、**保安規程の策定**等の**保安規制**を課す。
- 試掘や貯留事業に起因する**賠償責任**は、被害者救済の観点から、**事業者の故意・過失によらない賠償責任（無過失責任）**とする。

（参考２）貯留事業に関するフロー



2．CO2の導管輸送事業に係る事業規制・保安規制の整備

（1）導管輸送事業の届出制度の創設

- CO2を貯留層に貯留することを目的として、**CO2を導管で輸送する者は、経済産業大臣に届け出なければならない**ものとする。

（2）導管輸送事業者に対する規制

- 正当な理由なく、**CO2排出者からの輸送依頼を拒むこと**や、**特定のCO2排出者を差別的に取扱うこと**等を禁止するとともに、**料金等の届出義務**を課す。
- **技術基準適合義務**、**工事計画届出**、**保安規程の策定**等の**保安規制**を課す。

※海洋汚染防止法におけるCO2の海底下廃棄に係る許可制度は、本法律案に一元化した上で、海洋環境の保全の観点から必要な対応について環境大臣が共管する。

Aiming to develop a business environment in which private companies are able to launch CCS businesses in Japan by 2030, the bill is to stipulate provisions involving the following:

- establishing a licensing system for storage business and trial-drilling,
- establishing a storage right system and a trial-drilling right system, and
- developing business regulations and safety regulations pertaining to storage businesses and pipeline carbon dioxide transportation businesses.

4. Conclusion

Conclusion

- **The Government of Japan decided the 6th Energy Strategic Plan, and new Global warming countermeasure plan in October 2021: carbon neutrality (CN) by 2050, and -46% in 2030. Now The 7th Energy Strategic Plan is under development.**
- **To achieve carbon neutrality, in principle, primary energy should consist of renewable energy, nuclear energy, and fossil fuels with CCS. The combination of an increase in electrification ratio and low- and de-carbonized power supply plays a vital role in achieving net-zero emissions.**
- **CCS will play a certain role toward CN in Japan as well as the importance of global strategy including the utilization of overseas-made renewable energy and CCS through hydrogen, ammonia, e-methane (synthetic gas), and e-fuels (synthetic oil).**
- **Negative emission measures such as DACCS will also play an important role in achieving net-zero emissions including the opportunities in the implementations overseas with emission credit transfer.**
- **The transition measures and policies will also be very important. After 2030, CCS plays an important role also in Japan for the transition to the 2 °C or 1.5 °C long-term goal of the Paris Agreement.**
- **The policy schemes to mobilize large amounts of investment in decarbonized energy sources (e.g., nuclear power, CCS) with high risks for investments are important.**
- **The CCS act was enacted in May 2024, and carbon pricing policies are under development in Japan, and they also serve the incentive to CCS deployments.**