京都大学
KYOTO UNIVERSITY

Transitioning to a Net Zero Economy
- Insights from a Japanese Perspective

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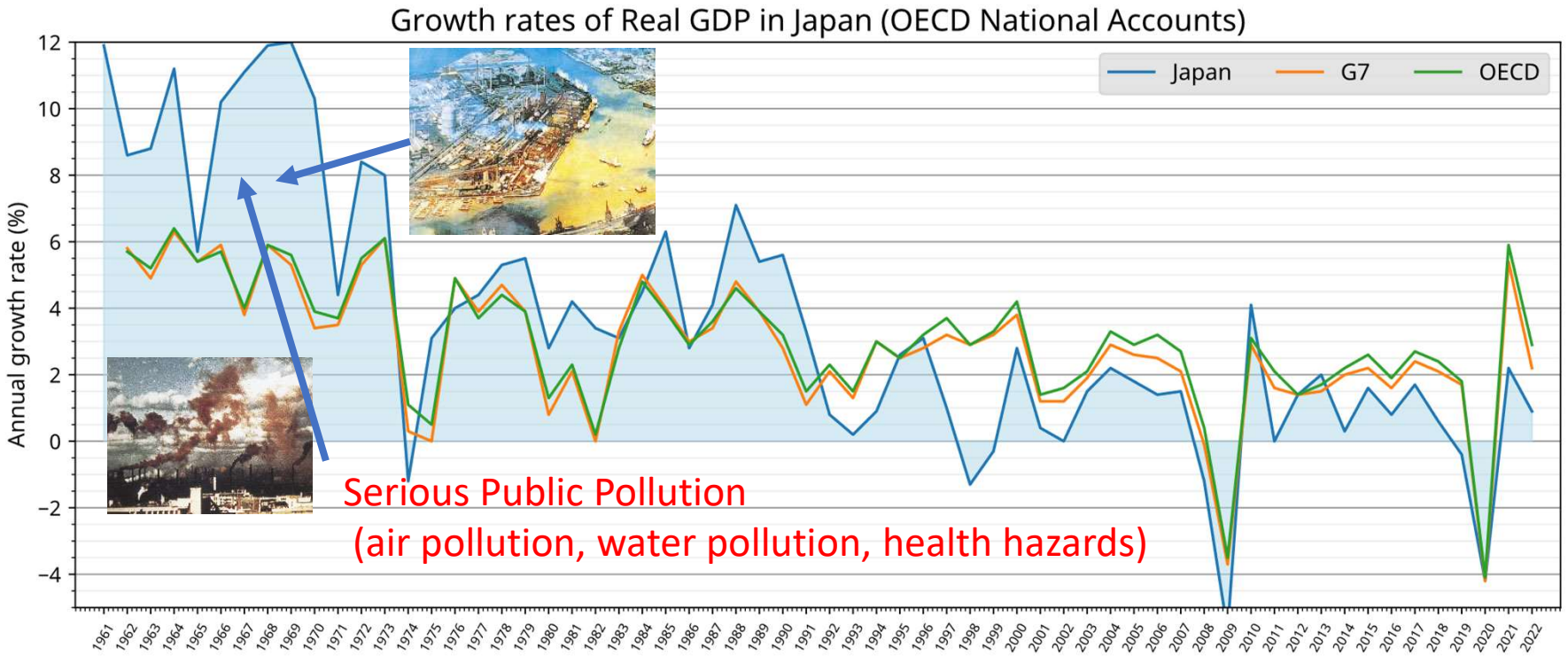
Where is this country?

In Japan Policy MIX for Sustainability solved Serious Public Pollution

Source: City of Kitakyushu



①Japan experienced a period of rapid economic growth from the 1950s to the 1970s.
②As a result, there was a strong recognition of the need to balance economic growth with environmental measures.
③For this reason, Japan has been working to achieve a balance between economic growth and environmental and energy policies.

In Japan Policy MIX for Sustainability

In Japan Policy mix for Sustainability (or Net Zero Economy)

Policy mix for Net Zero Economy

- The fundamentals of Japan's environmental, energy and economic policies are implemented through a policy mix.
- A policy mix use of multiple policy measures.
- 1. Laws and regulations
- 2. Use of economic measures

  (i) Taxation (environment or energy tax)

  (ii) Markets or Green Finace

  (iii) Subsidies (incentives)
- 3. educational methods
- 4. Information disclosure
- 5. Research and development

Environment-related Taxes in Japan

Energy Tax

Tax Items (Sovereign of Tax)	Taxable Objects	Tax Rates	Tax Revenue (FY2015)(JPY)	Revenue Spent for
Gasoline Tax (Nation)	Gasoline; transferred from plants, or delivered from bonded areas.	JPY 48.6/ℓ (Permanent: JPY 24.3/ℓ)	2,466 bill.	General budget
Local Gasoline Tax (Nation)		JPY 5.2/ℓ (Permanent: JPY 4.4/ℓ)	263.8 bill.	General budget (100% distributed to prefectures)
Oil and Gas Tax (Nation)	Oil and Gas for Vehicles; transferred from stations, or delivered from bonded areas.	JPY 17.5/kg	20 bill.	General budget (50% distributed to prefectures)
Diesel Oil Delivery Tax (Prefectures)	Diesel Oil; delivered by traders with accompanying actual delivery of the oil.	JPY 32.1/ℓ (Permanent: JPY 15.0/ℓ)	938.3 bill	General budget
Aviation Fuel Tax (Nation)	Aviation Fuel; loaded to aviation.	JPY 18.0/ℓ ※Special rate until Mar. 2019 (Permanent: JPY 26.0/ℓ)	65.6 bill.	Public works for airports (2/9 is distributed to prefectures and municipalities relevant for airports)
Petroleum and Coal Tax (Nation)	Petroleum,/oil products, Gaseous Hydrocarbon, and Coal; transferred from the field, or delivered from bonded areas.	• Pet/oil products JPY 2,040/kℓ • LPG, LNG, etc. JPY 1,080/t • Coal JPY 700/t	628 bill.	Policies for stable fuel supply (Development of oil and natural gas, and establishment of reserves, to ensure stable and low-cost supply of fossil fuel)
Tax for Climate Change Mitigation	Additional rate corresponding to CO_2 emission ※Effective from Oct. 2012.	• Pet/oil products JPY 760/kℓ • LPG, LNG, etc. JPY 780/t • Coal JPY 670/t	—	Policies for modernization of the energy demand/supply structure (Measures for energy-efficiency and new energy, and control measures for energy-originated CO2 emission, to establish a stable and appropriate energy structure, adapted with state of econ & env.)
Electric Power Development Promotion Tax (Nation)	Sold Electricity; delivered by general electric enterprises.	JPY 375/1000kwh	323 bill.	Policy measures for where power plants are located (Supply of grant under the Act on Development of Region Surrounding Power Generation Facilities, fiscal support for safety measures in the region, and other fiscal support for establishment and smooth operation of facilities for power generation) Policy measures for utilization of power sources (Fiscal support for utilization and security of power generation facilities, and for smooth supply of electricity from power plants) Measures for nuclear safety regulation (Measures to ensure safety of nuclear power station (includes supply of grant to the JNES))

Total. 4,704.7 bill.

Vehicle Tax

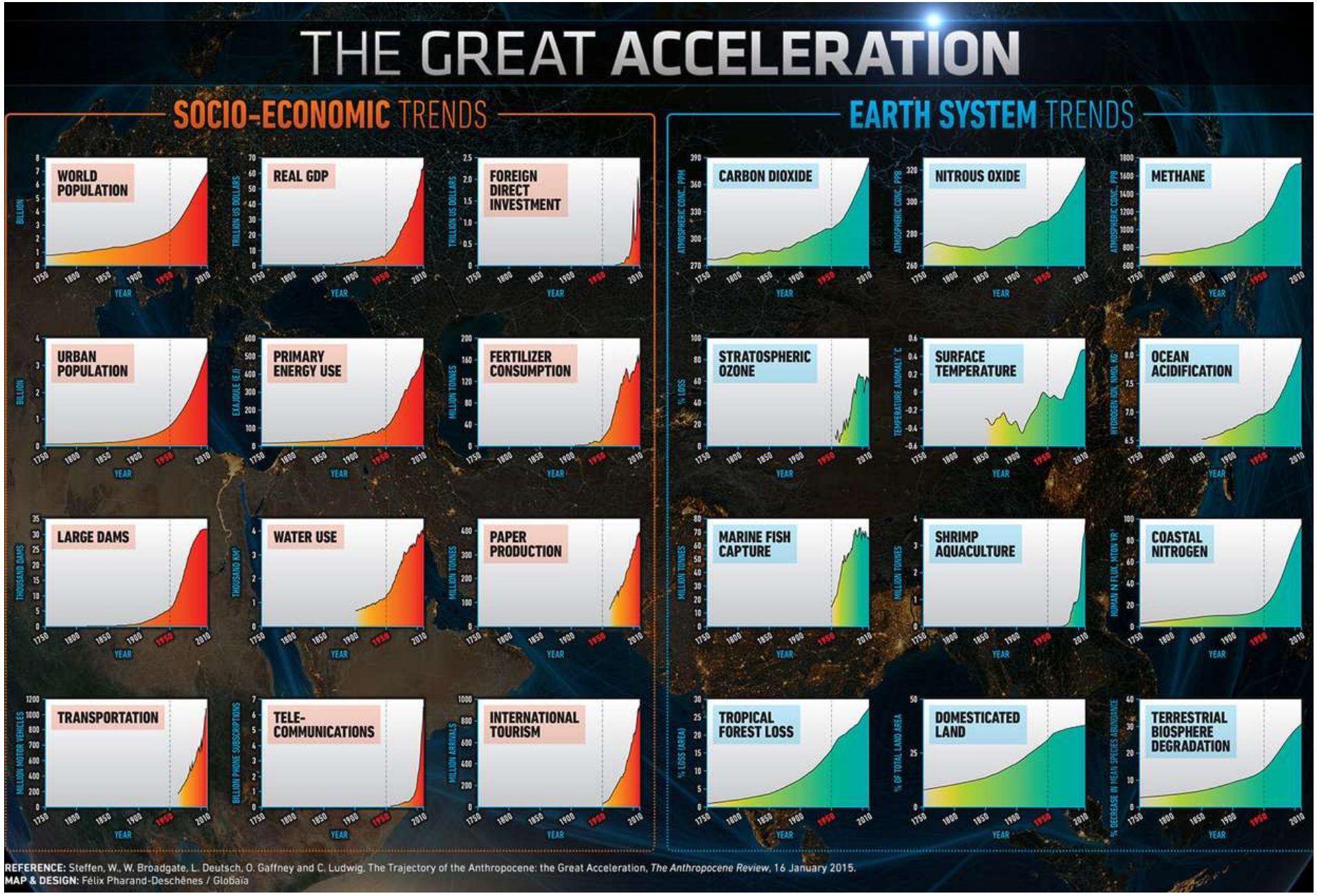
Motor Vehicle Weight Tax (Nation)	Automobile; when issuance of certification for the automobile inspection, and of designated car number (light vehicle)	[Ex.] Passenger car Per 0.5t of vehicle weight; • Home use JPY 4,100/year • Business JPY 2,600/year (Permanent: JPY 2,500 for both)	630.7 bill.	General budget (407/1000 distributed to municipalities) Part of the revenue is allocated for compensation to victims of public pollution.
Automobile Tax (Prefectures)	Automobile; owned on April 1	[Ex.] Passenger, home use 1,500～2,000cc JPY 39,500/year	1,539.7 bill.	General budget
Light Vehicle Tax (Municipalities)	Light vehicle or motorcycle; owned on April 1	[Ex.] Light vehicle, home use • From FY2015 JPY 10,800/year (Before FY2015 JPY 7,200/year)	199.9 bill.	General budget
Automobile Acquisition Tax (Prefectures)	Automobile; when acquired.	• Home use 3% of car price • Business, 2% of car price (Permanent: 3% for both)	109.6 bill.	General budget (95/100 × 7/10 ia distributed to municipalities)

Total. 2,479.9 bill.

Policy MIX by Multi-Stakeholder

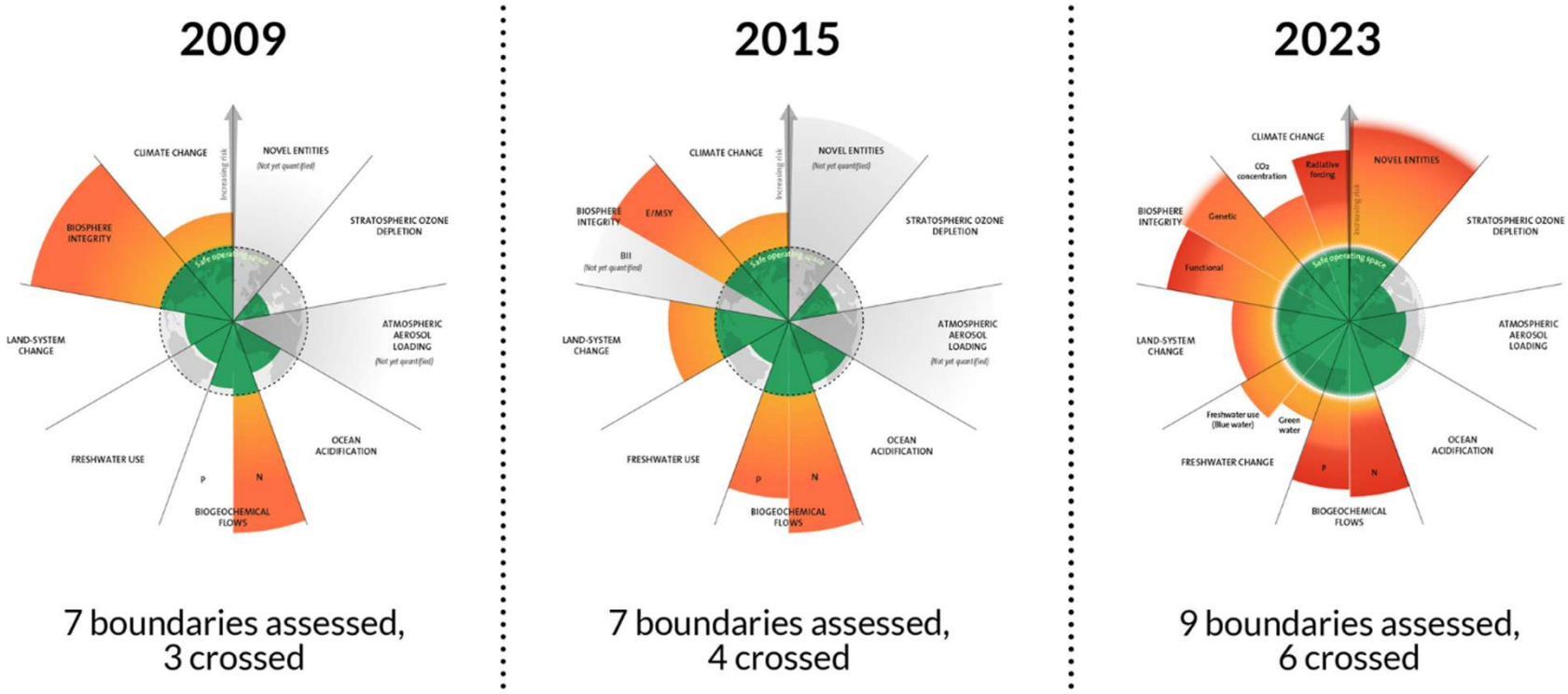
- Multi-governance is necessary to achieve a policy mix.
- Multi-governance means that cooperation and collaboration between diverse stakeholders such as government organizations, companies, local communities, research institutions/universities, etc. is extremely important.
- In Japan, we are dealing with serious pollution and climate change issues through such policy mixes and multi-governance.

The Earth system has already reached its limits



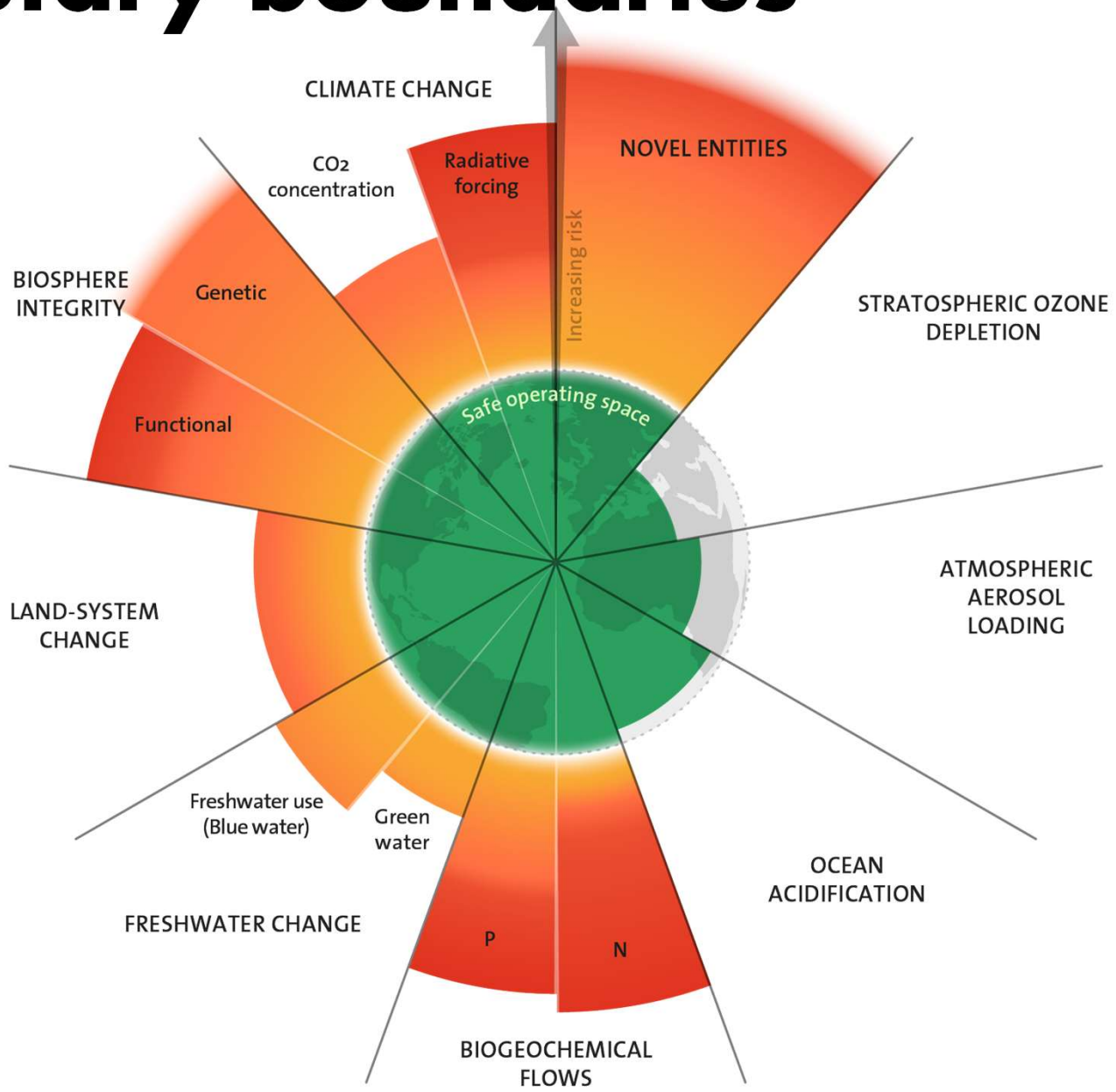
REFERENCE: Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig. The Trajectory of the Anthropocene: the Great Acceleration, *The Anthropocene Review*, 16 January 2015.
MAP & DESIGN: Félix Pharand-Deschênes / Globaïa

Planetary boundaries



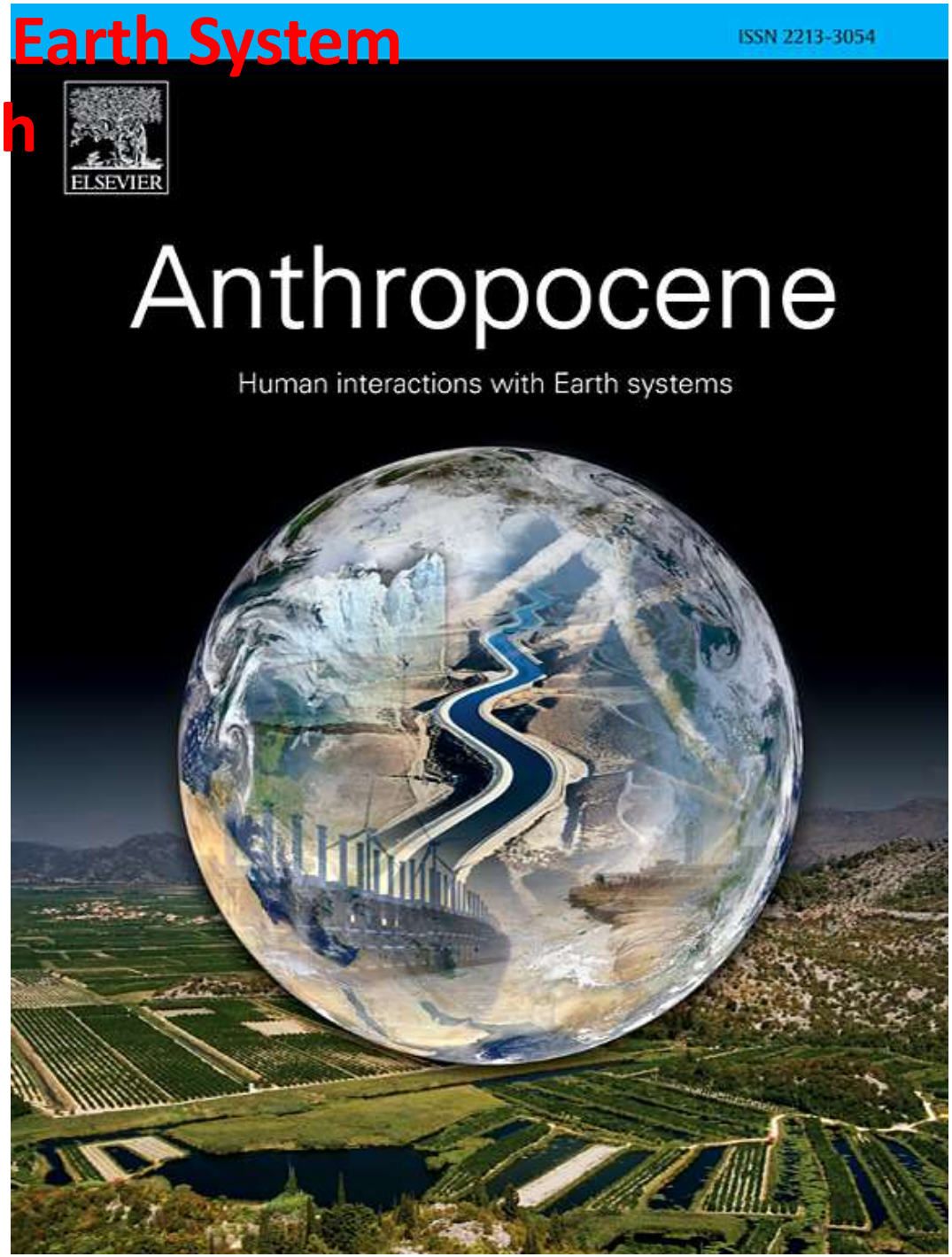
The evolution of the planetary boundaries framework. Licenced under CC BY-NC-ND 3.0 (Credit: Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009)

Planetary boundaries



Human interaction with Earth System
The Anthropocene epoch

Have we entered a new phase of planetary history?

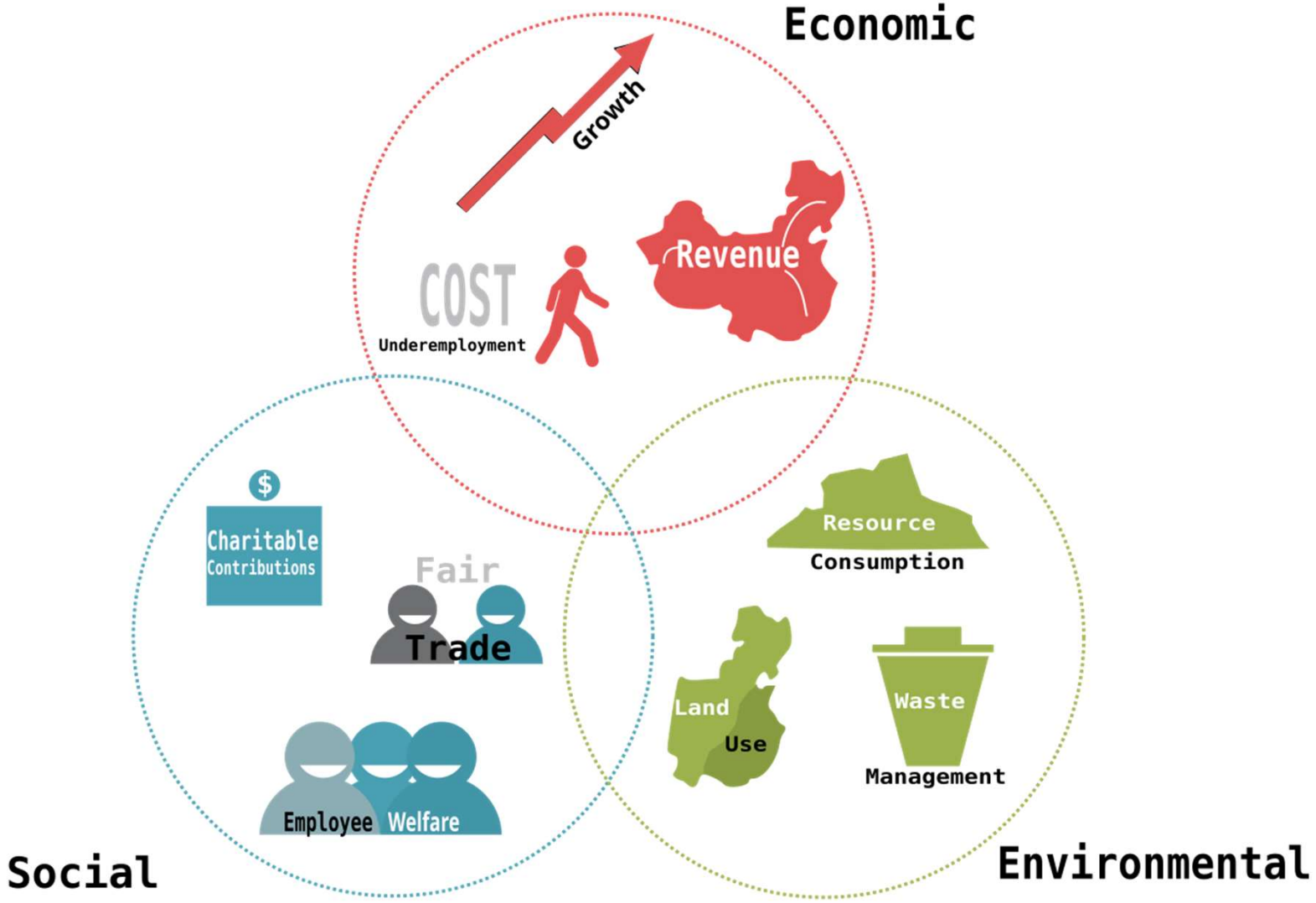


Beyond Anthropocene

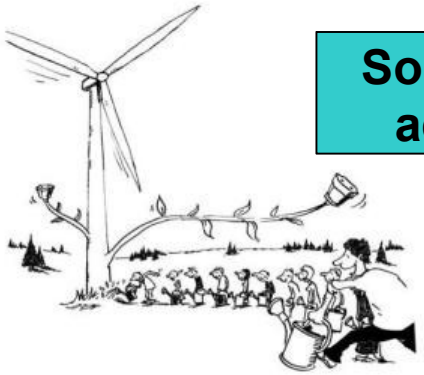
- **What is the basic perspective for achieving a net zero economy?**

- It is to ensure a balance between economic growth and the environment and welfare.

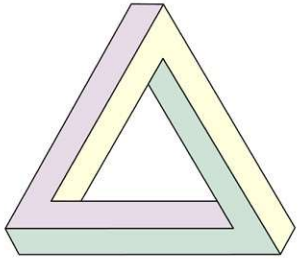
Theory of Balance between Economic Growth and the Environment and Social welfare by Policy MIX


Economic
Growth
Revenue
COST
Underemployment
$
Charitable
Contributions
Fair
Trade
Employee
Welfare
Resource
Consumption
Land
Use
Waste
Management
Social
Environmental

Social Acceptance for Sustainability



Socio-political acceptance

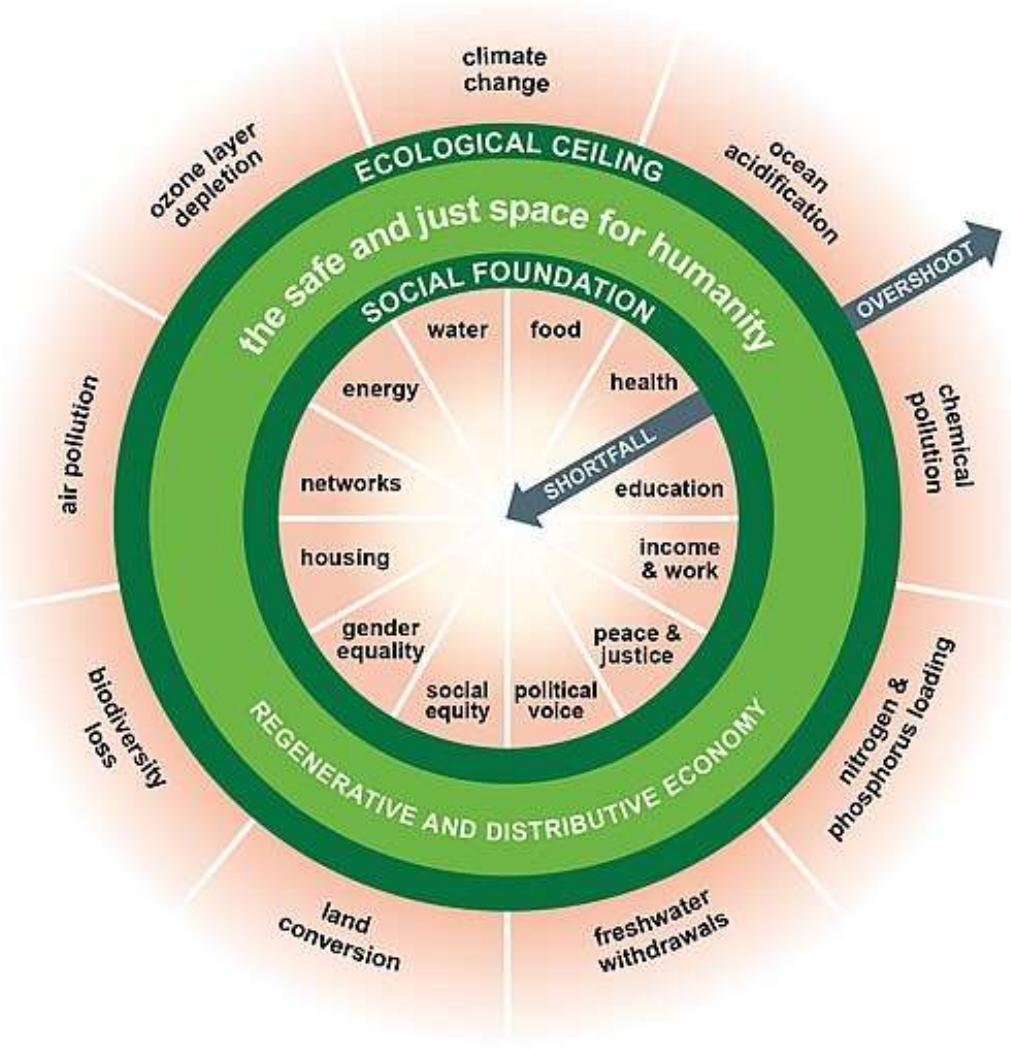


Community acceptance

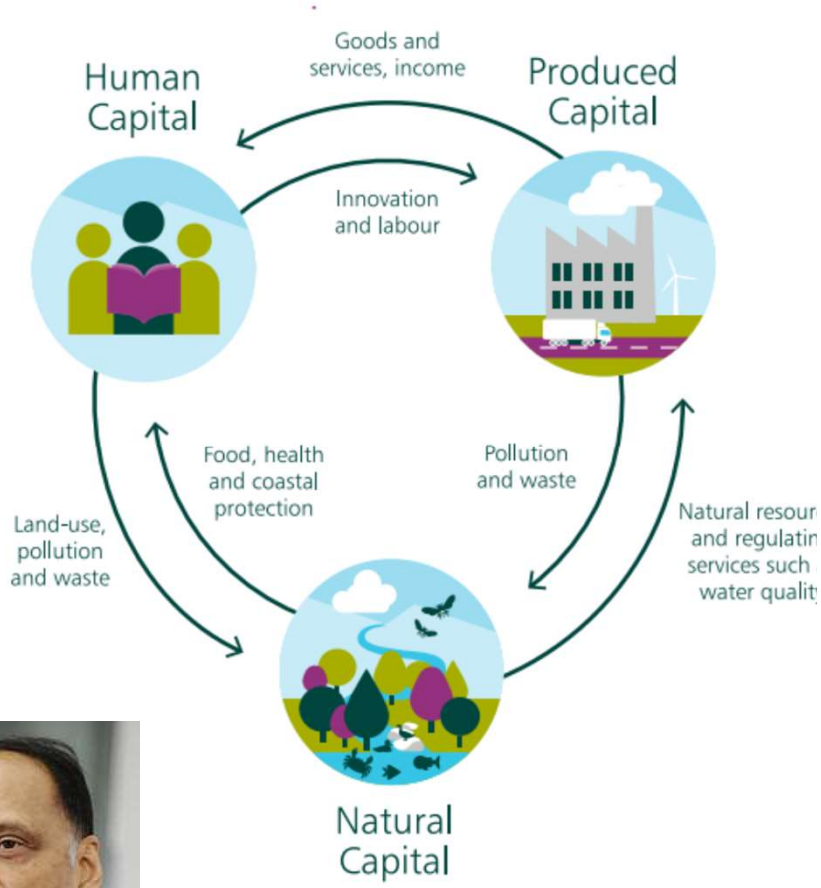
Market acceptance

Doughnut Economics

Kate Raworth



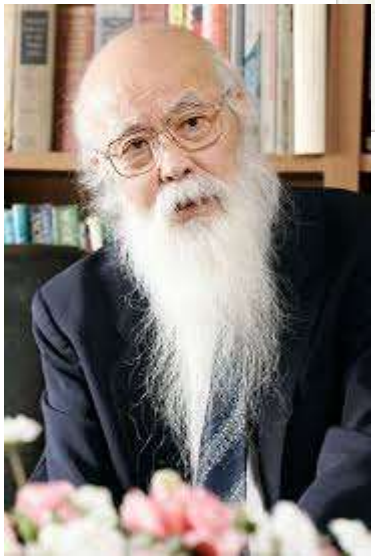
For Natural Capital



Sir Partha Sarathi Dasgupta

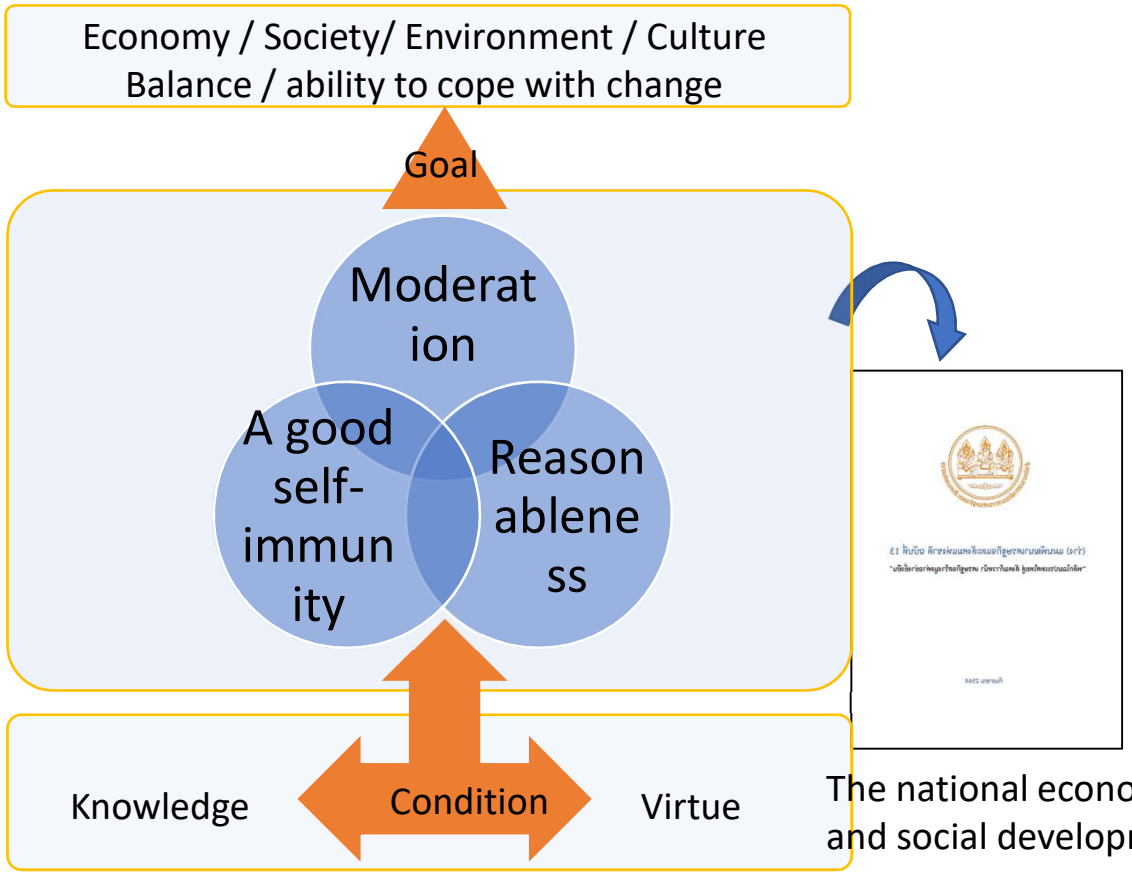
Social overhead Capital

- Social common capital refers to the social apparatus that enables all people living in a country or a specific region to lead a prosperous economic life, develop a good culture, and maintain a humanly attractive society in a sustainable and stable manner.
- It is the common property of society as a whole, and is managed and operated by professional groups involved in the respective social common capital, based on their professional knowledge and professional ethics.
- To embody the ideals of liberalism in the true sense of the word, oriented toward a society that preserves the human dignity of each individual, maintains the independence of the soul, and secures the maximum amount of civil liberties.



Hirofumi Uzawa / 1928-2014. He graduated from the University of Tokyo with a bachelor's degree in mathematics and entered the graduate school of the same university as a special research student. 1956 moved to Stanford University, where he was an assistant professor in the economics department and then an associate professor at the University of California. 1969 became a professor in the economics department of the University of Tokyo, and later a professor at Niigata University and Chuo University. In 1969, he became a professor at the Faculty of Economics, University of Tokyo, and later a professor at Niigata University and Chuo University.

Sufficiency Economy Philosophy (SEP)



The national economic
and social development plan

SEP can apply in various level

Reference; Sufficiency Economy Philosophy (NESDC, 2014)

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The influence of stakeholder on a company's sustainable practice: Insights from the Japanese perspective

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Primary stakeholder
Secondary stakeholder
Industrial sector
Service sector

ABSTRACT

Sustainable development operations in the business sector are continuously growing. Motivation for sustainability issues and stakeholder identification have been explored for strategy development and prioritization. However, the understanding of the relationship between stakeholder groups and sustainability practices is limited. This study focuses on primary and secondary stakeholders from stakeholder theory and examines sustainability issues in the business context. Through a questionnaire survey, the research aims to validate the direct impact of stakeholder groups on each dimension of sustainable business. The survey was conducted among employees of Japanese companies from both the industrial and service sectors, and confirmatory analysis was performed using structural equation modeling. Our results demonstrate that both primary and secondary stakeholders are involved in all aspects of sustainable practices. We observed that primary stakeholder groups primarily influenced sustainable practices in the industrial sector, whereas secondary stakeholder groups predominantly affected the service sector. An examination of specific actors revealed that suppliers and the media played a significant role in all dimensions of business sustainability. Finally, this study supports the assertion that normative pressure may be the primary factor that convinces companies to adapt successfully and achieve their sustainable development goals.


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In Japan Policy mix for Sustainability (or Net Zero Economy)

Carbon Neutral

Transitioning to a Net Zero Economy

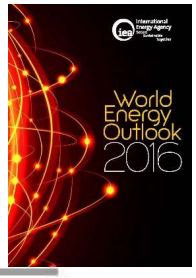
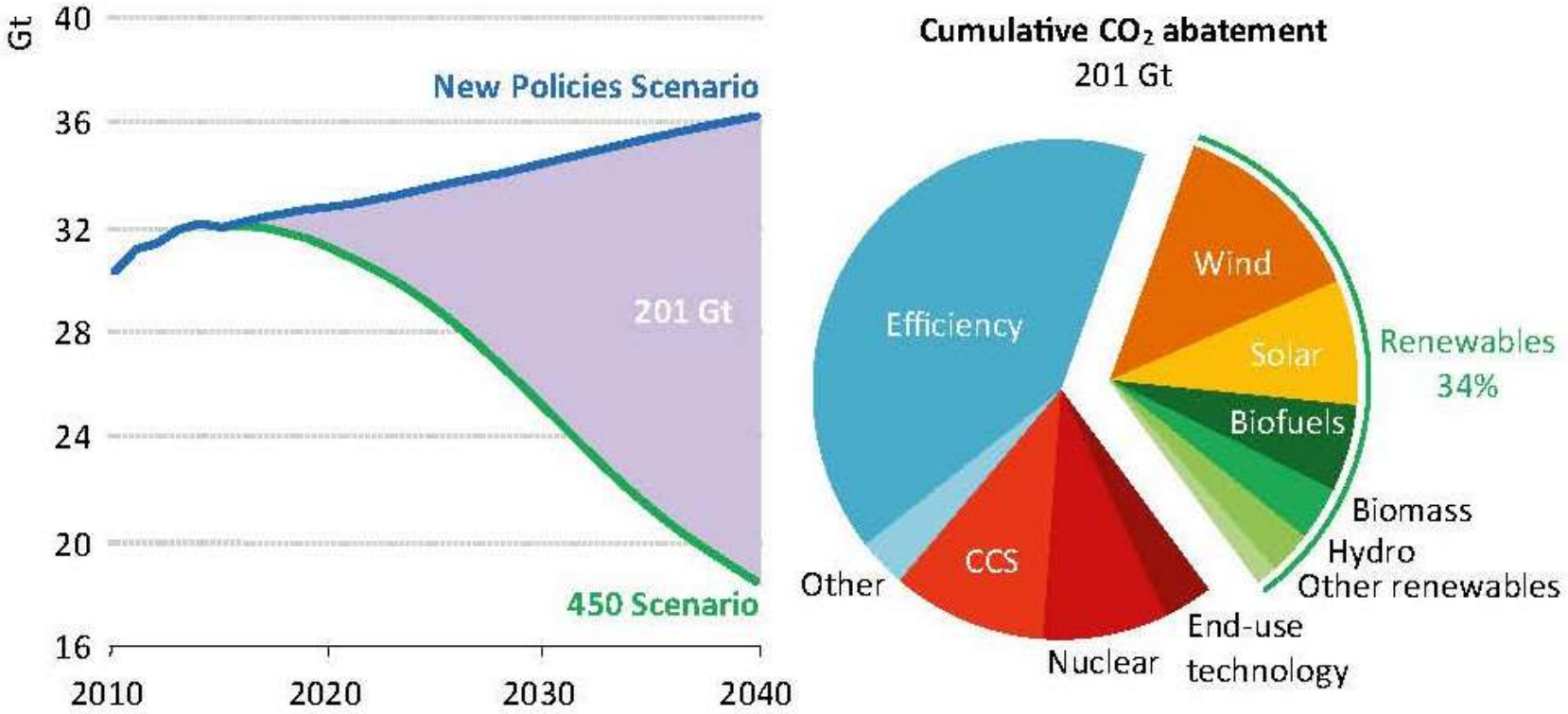


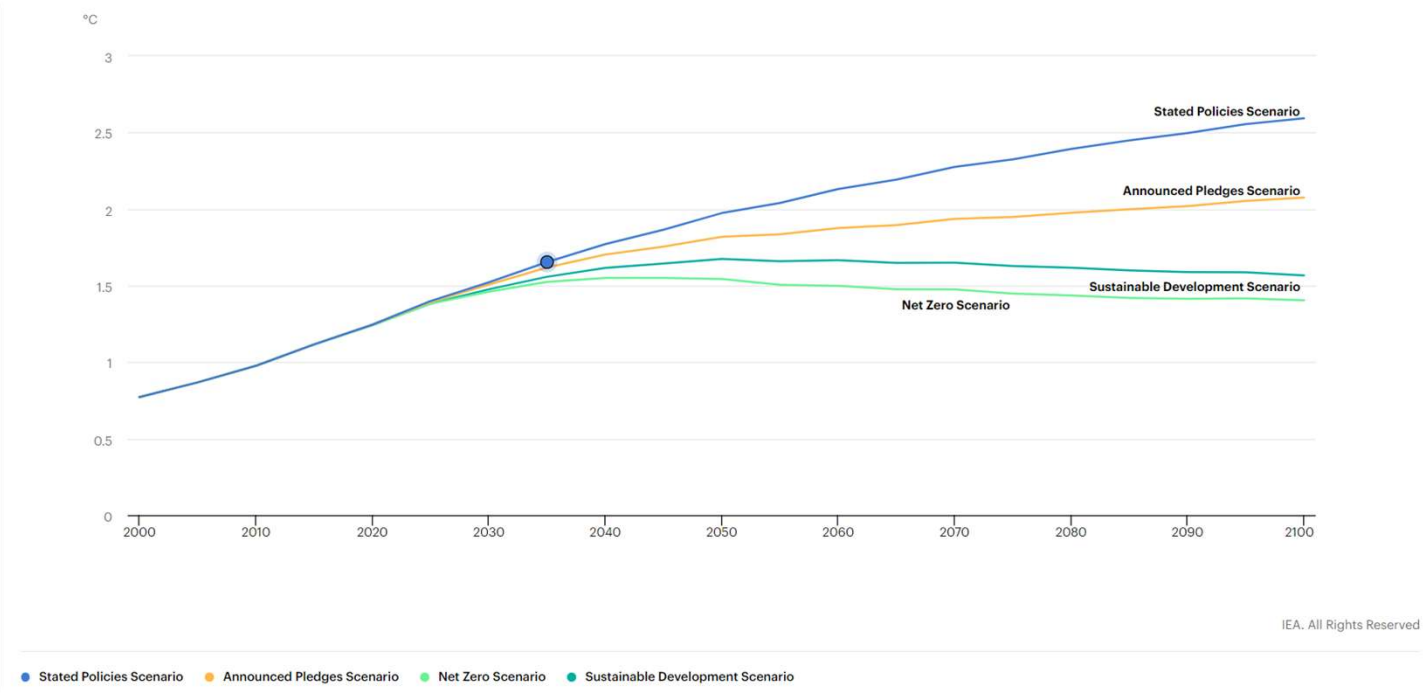
Figure 10.16 ▷ Global energy-related CO_2 emissions by scenario and additional CO_2 abatement by measure in the 450 Scenario



Renewable energy ramps up faster in the 450 Scenario, abating an additional 69 Gt of CO_2 emissions (2015-2040) relative to the New Policies Scenario

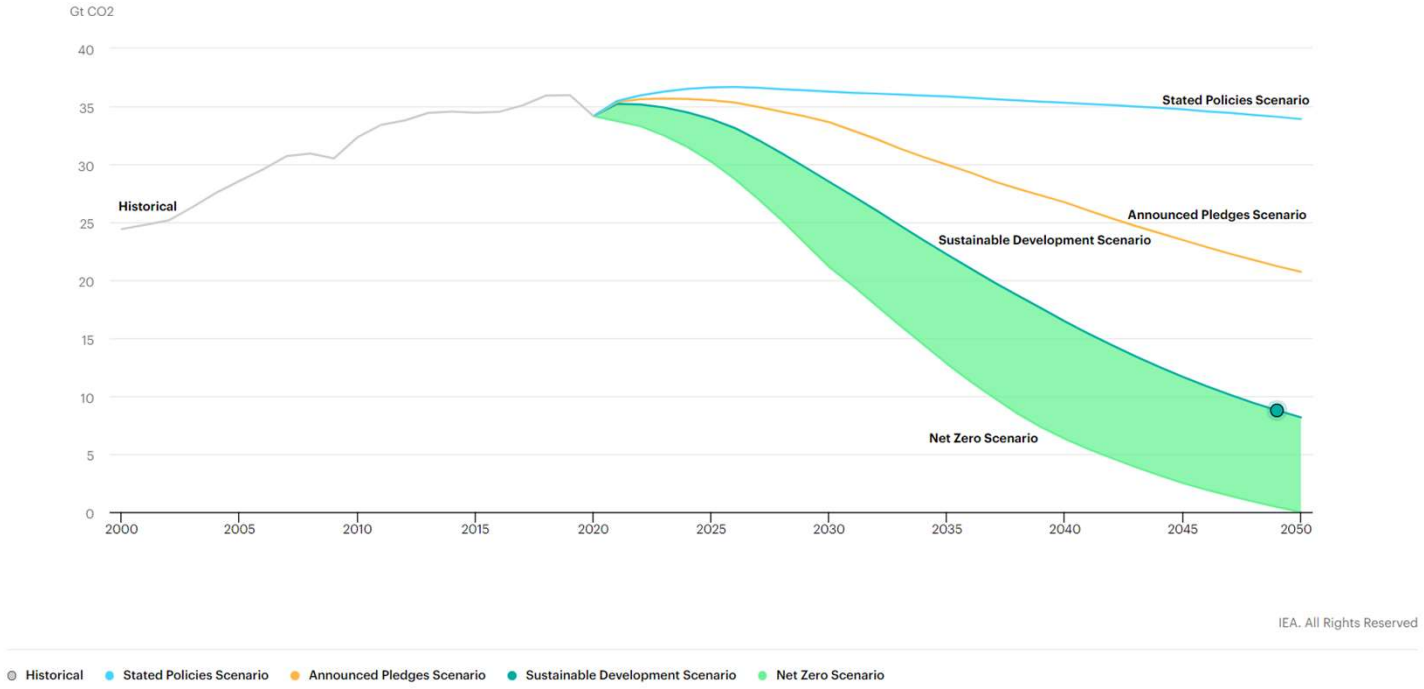
パリ協定/　2050年の80％削減を達成しようとすれば、”450シナリオ”に準拠する必要がある

Global median surface temperature rise in the WEO-



出典：IEA　World Energy Outlook

CO2 emissions in the WEO-2021 scenarios, 2000-2050



出典：IEA　World Energy Outlook

Carbon Neutral in JAPAN

In taking on the challenge of becoming carbon neutral by 2050 in Japan, we believe it is important to strategically promote economic and social reforms, including the creation of new regions and lifestyle changes, to create a virtuous cycle between the economy and the environment as a new growth strategy for Japan, to generate world-leading innovation and contribute to the realization of carbon neutrality, and to broaden the scope of our efforts by continuing to engage in dialogue and communication with all entities, regardless of generation or field. We believe that it is important to continue dialogue and communication among all actors, regardless of generation or field, and to broaden the scope of our efforts.(by Suga)

Dr.Akira Yoshino/
Nobel Prize in Chemistry

Prime Minister Suga(2020~2021)

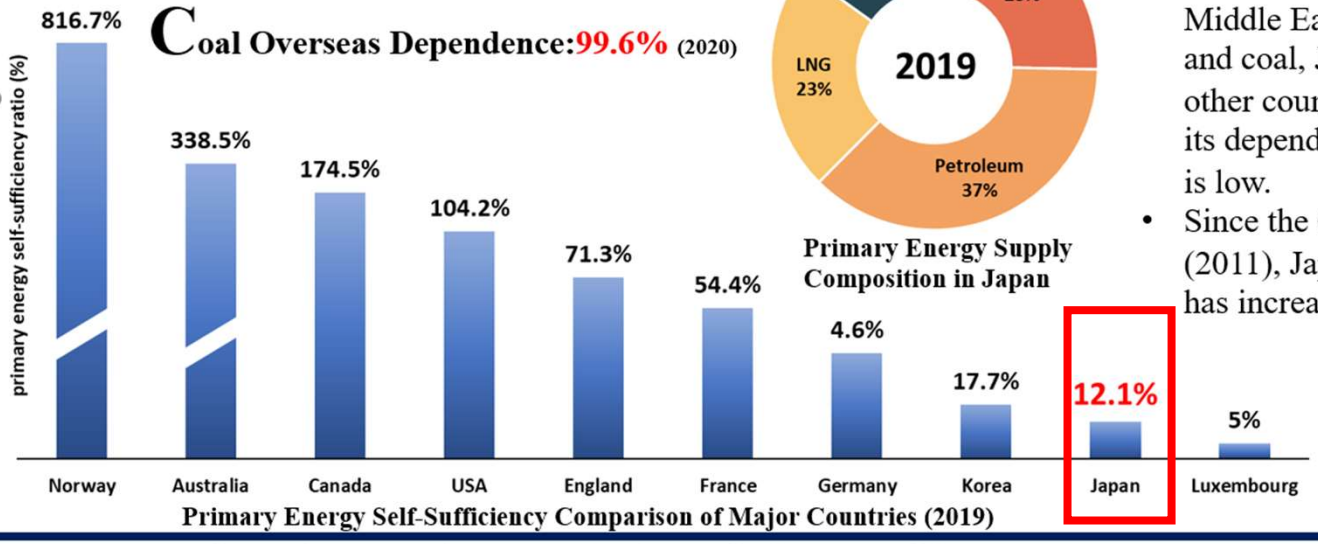
https://www.kantei.go.jp/jp/99_suga/actions/202012/17carbon_neutral.html

Energy Situation in Japan (Supply-side)

Crude Oil Overseas Dependence:
99.7% (2020)

LNG (Liquefied Natural Gas) Overseas Dependence: 97.7% (2020)

Coal Overseas Dependence:99.6% (2020)



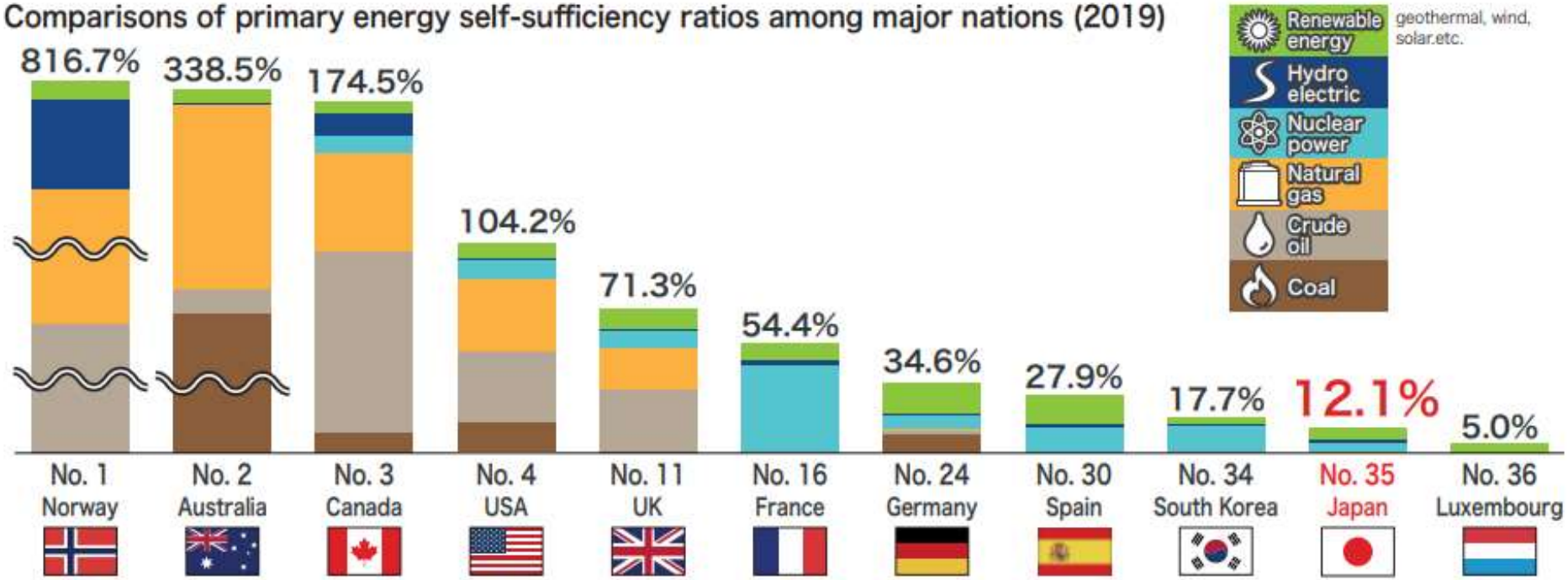
Primary Energy Self-Sufficiency Comparison of Major Countries (2019)

Primary Energy Supply Composition in Japan

- Japan's self-sufficiency rate for fiscal 2019 is 12.1%, which is low compared to other OECD countries.
- Japan is about 90% dependent on the Middle East region for crude oil; for LNG and coal, Japan relies on imports from other countries, including Asia, although its dependence on the Middle East region is low.
- Since the Great East Japan Earthquake (2011), Japan's dependence on fossil fuels has increased and been 84.8% in FY2019.

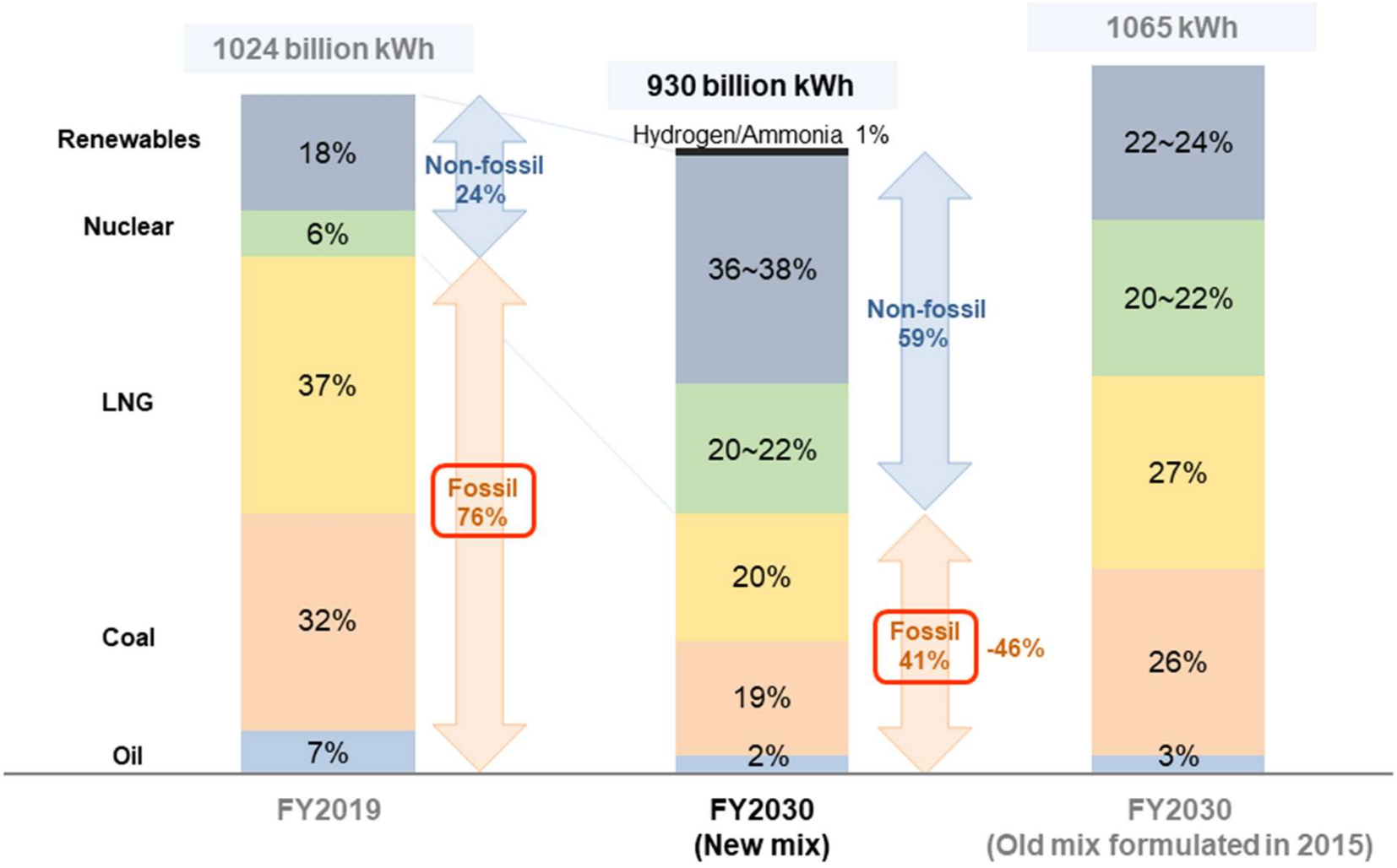
Data source: Agency for Natural Resources and Energy, METI (2020), Comprehensive Energy Statistics

Comparisons of primary energy self-sufficiency ratios among major nations (2019)



Source: Estimates for 2019 from IEA "World Energy Balances 2020", except for data for Japan, which are confirmed values of FY 2019, derived from "Comprehensive energy statistics of Japan", Agency for Natural Resources and Energy. ＊ The ranks in the table are those of the 36 OECD member countries.

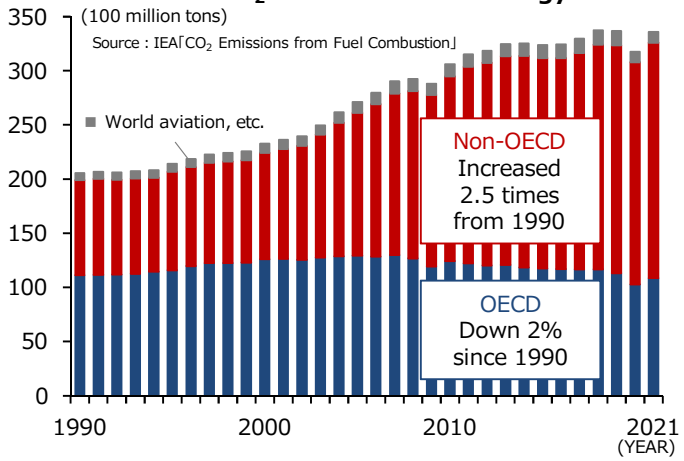
Energy MIX 2030 IN JAPAN



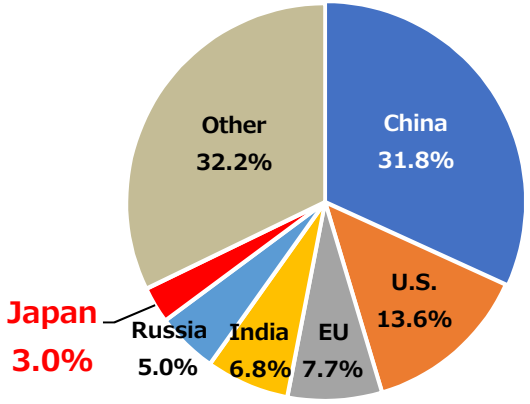
Challenges and Responses to Achieve GX and Net-Zero GHG EmissionsProgress in Reducing Greenhouse Gas Emissions

- The increase in emissions in developing countries has led to an **increase in global emissions** (**Japan's emissions are 3% of the global total**).
- **In order to achieve net-zero GHG emissions, it is important to aim for a common goal under various and realistic pathways according to each country's circumstances.**
- **Japan is making steady progress** in reducing emissions against its FY2030 reduction target (**on-track**).

«Global CO_2 emissions from energy»



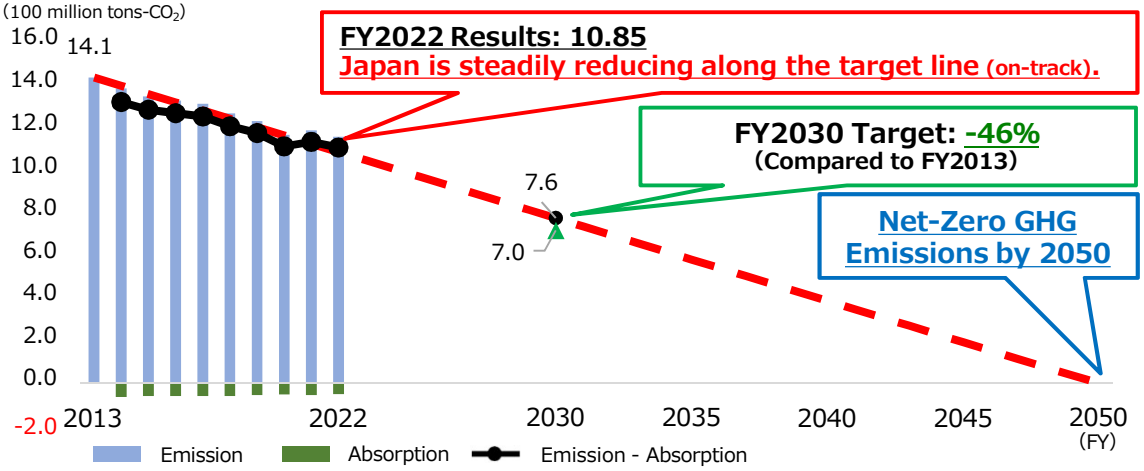
«Ratio of global CO_2 emissions from energy(2021)»



Source : IEA「CO_2 Emissions from Fuel Combustion」

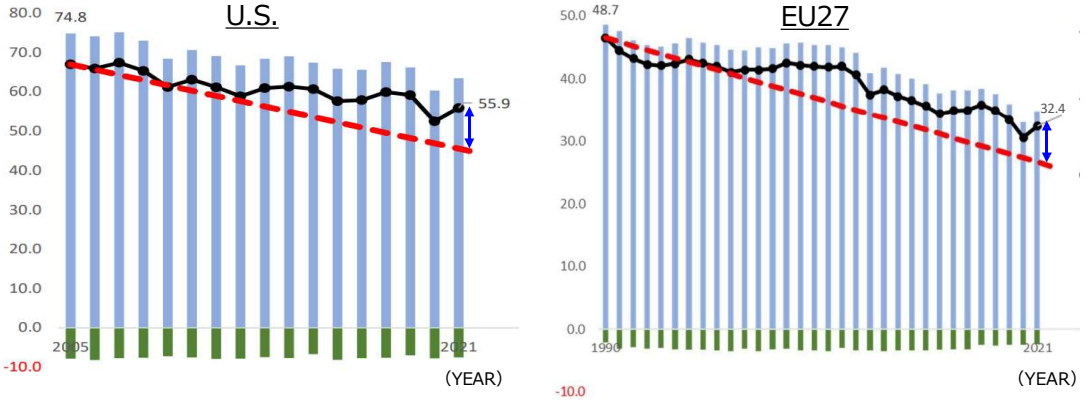
«Greenhouse gas emissions and absorption in Japan»

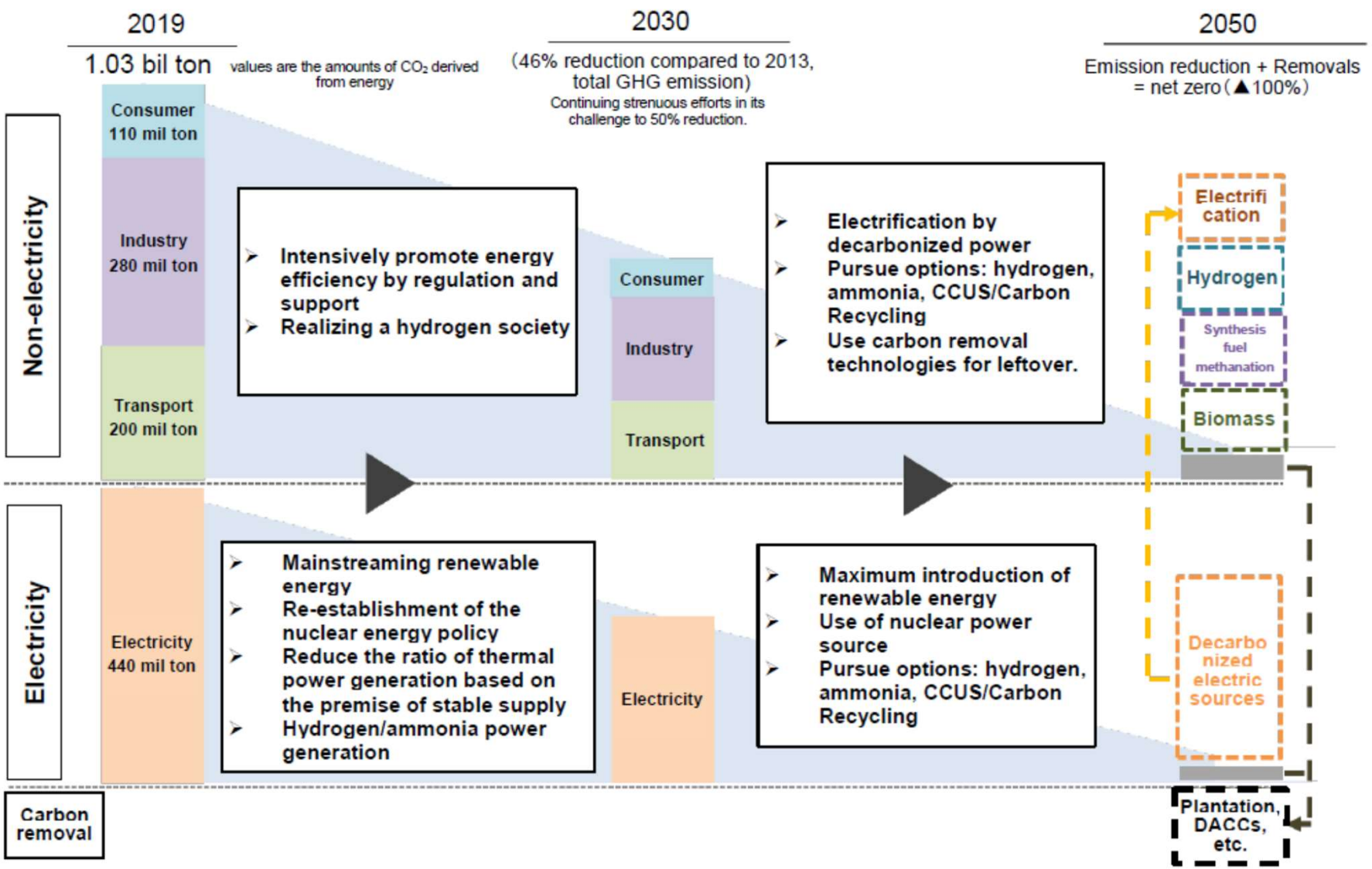
Source : Ministry of the Environment



«Greenhouse gas emissions and absorption in the U.S. and the EU»

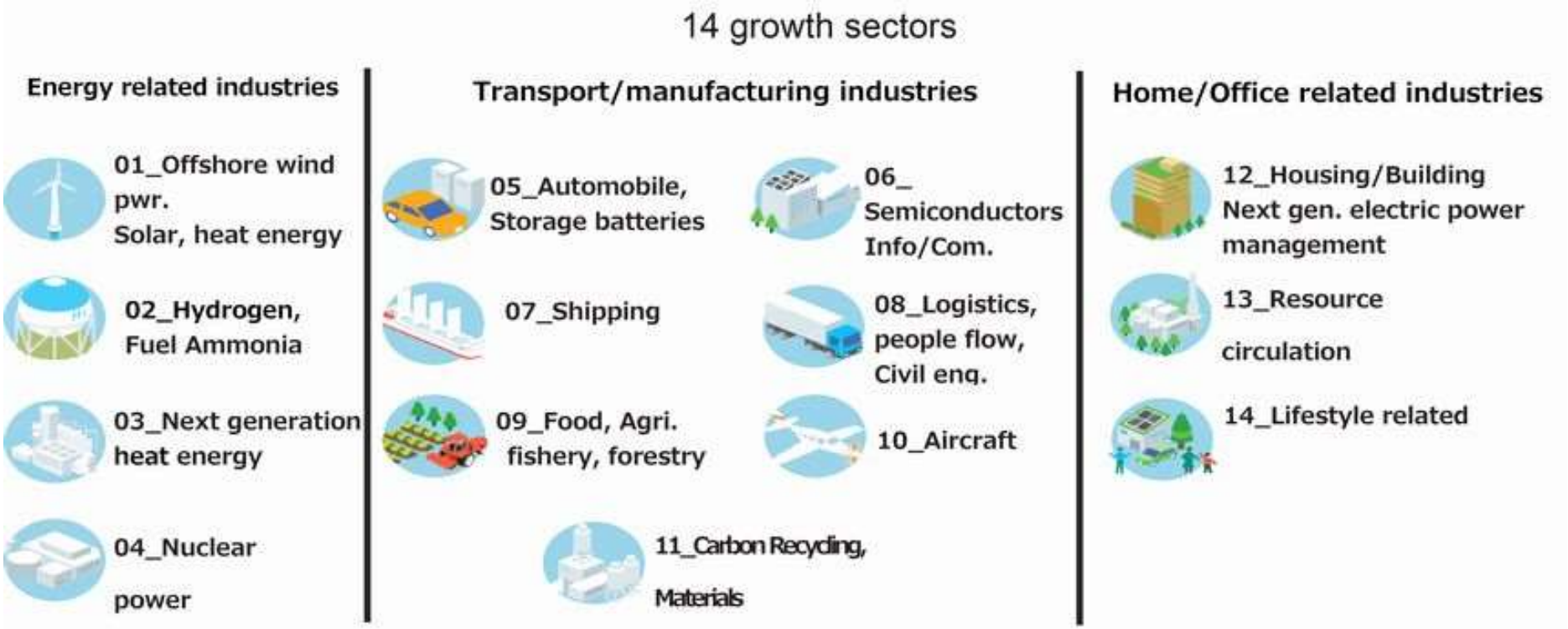
Source: Compiled by Ministry of the Environment based on UNFCCC「Greenhouse Gas Inventory Data」



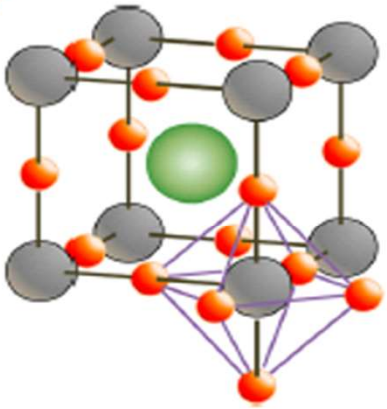

2019
1.03 bil ton
values are the amounts of CO_2 derived from energy
2030
(46% reduction compared to 2013, total GHG emission)
Continuing strenuous efforts in its challenge to 50% reduction.
2050
Emission reduction + Removals = net zero (▲100%)
Non-electricity
Consumer 110 mil ton
Industry 280 mil ton
Transport 200 mil ton
Intensively promote energy efficiency by regulation and support
Realizing a hydrogen society
Consumer
Industry
Transport
Electrification by decarbonized power
Pursue options: hydrogen, ammonia, CCUS/Carbon Recycling
Use carbon removal technologies for leftover.
Electrifi cation
Hydrogen
Synthesis fuel methanation
Biomass
Electricity
Electricity 440 mil ton
Mainstreaming renewable energy
Re-establishment of the nuclear energy policy
Reduce the ratio of thermal power generation based on the premise of stable supply
Hydrogen/ammonia power generation
Electricity
Maximum introduction of renewable energy
Use of nuclear power source
Pursue options: hydrogen, ammonia, CCUS/Carbon Recycling
Decarbo nized electric sources
Carbon removal
Plantation, DACCs, etc.


Green Growth
Strategy

Green Growth Strategy in Japan

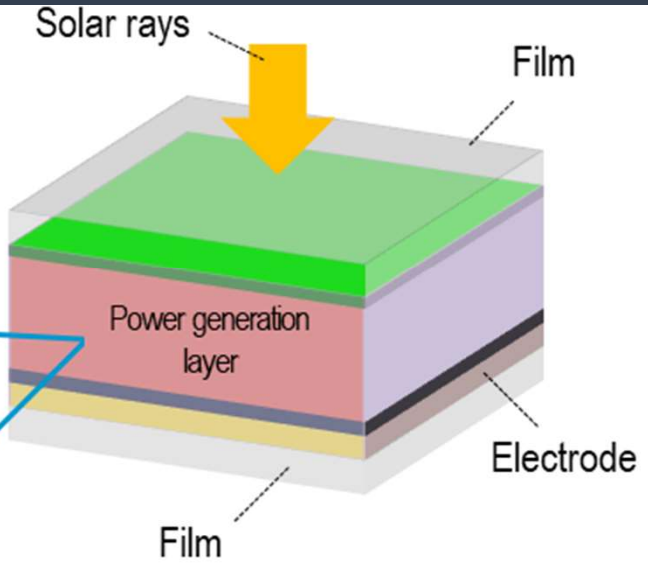


New TECH -Perovskite Solar



A = methylamine (CH3NH3+), etc.
B = lead (Pb2+), etc.
X = iodine (I-), etc.

Perovskite crystal structure (general formula: ABX3)



Indoor/small-sized

Attached to relatively small appliances for specific uses such as IoT devices

(Source) Enecoat Technologies Co., Ltd.

- Installation on devices with short lifespans **may be a way to cope with the shorter operational life of the cells.** If large-area module efficiency becomes technically viable, **small-sized products with high added value can be produced.**
- **To acquire a market, it is essential to pursue uniqueness and high added value in collaboration with users.**

Lightweight/flexible

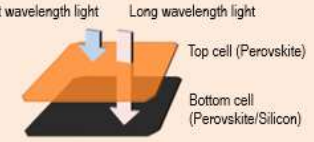
Installation on spaces where it is hard to install conventional solar cells (installation on building walls and roofs with a small safe load)

(Source) Sekisui Chemical Co., Ltd.

- **Scaling up perovskite manufacturing** would require a high yield and improved cell durability, which are both **challenging**. If large scale manufacturing is realized, perovskite solar cells will be installed in places **where it is hard to install conventional solar cells**, leading to the expansion of solar power generation.
- **Large-scale manufacturing technologies** are the key. Japan is **in the forefront for acquiring patents for cell durability**. Additionally, **the accumulation of manufacturing know-how is essential,** although it is unsuitable for patent application.

Ultra-efficient type

In fields that require high energy density



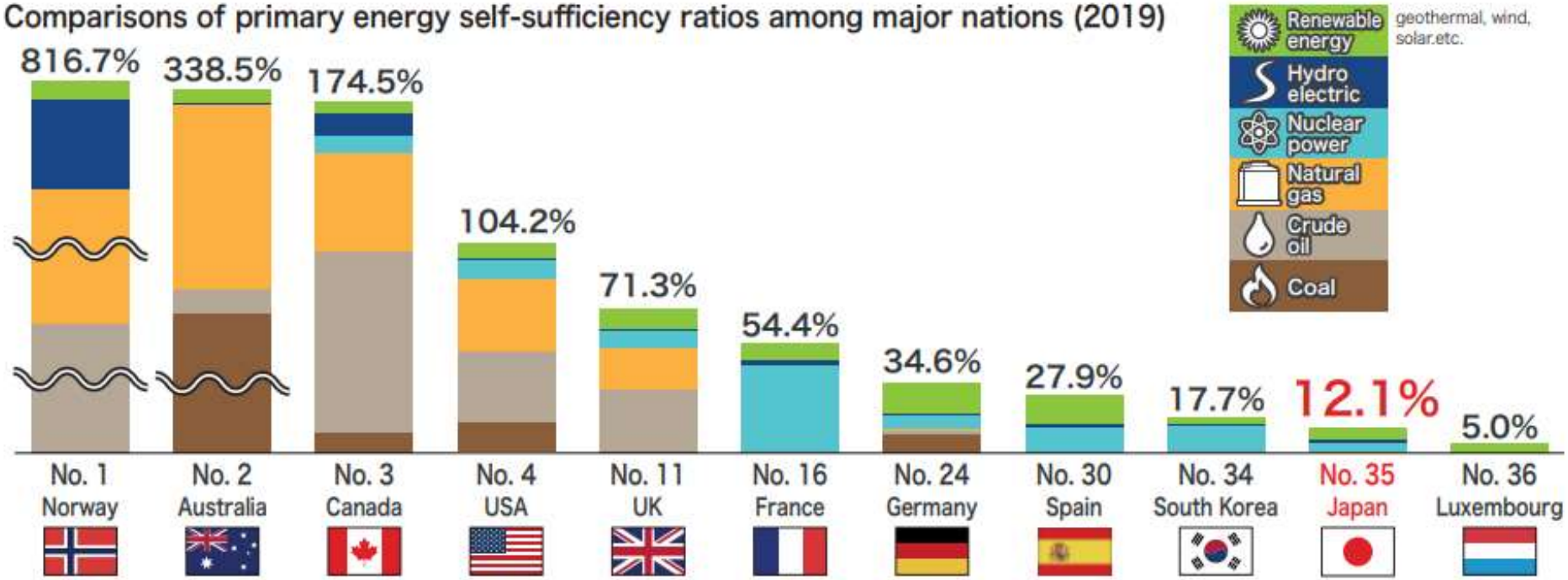
Conceptual diagram showing a tandem solar cell

- In fields such as transportation and aviation, high energy density is required due to limited spaces available for installation. It is essential to **develop ultra-efficient tandem solar cells**.
- Cost reduction is the key **to realize prices that commercially justify ultra-efficiency. Scaling up perovskite manufacturing** would require a high yield and improved cell durability, which are both **challenging**.

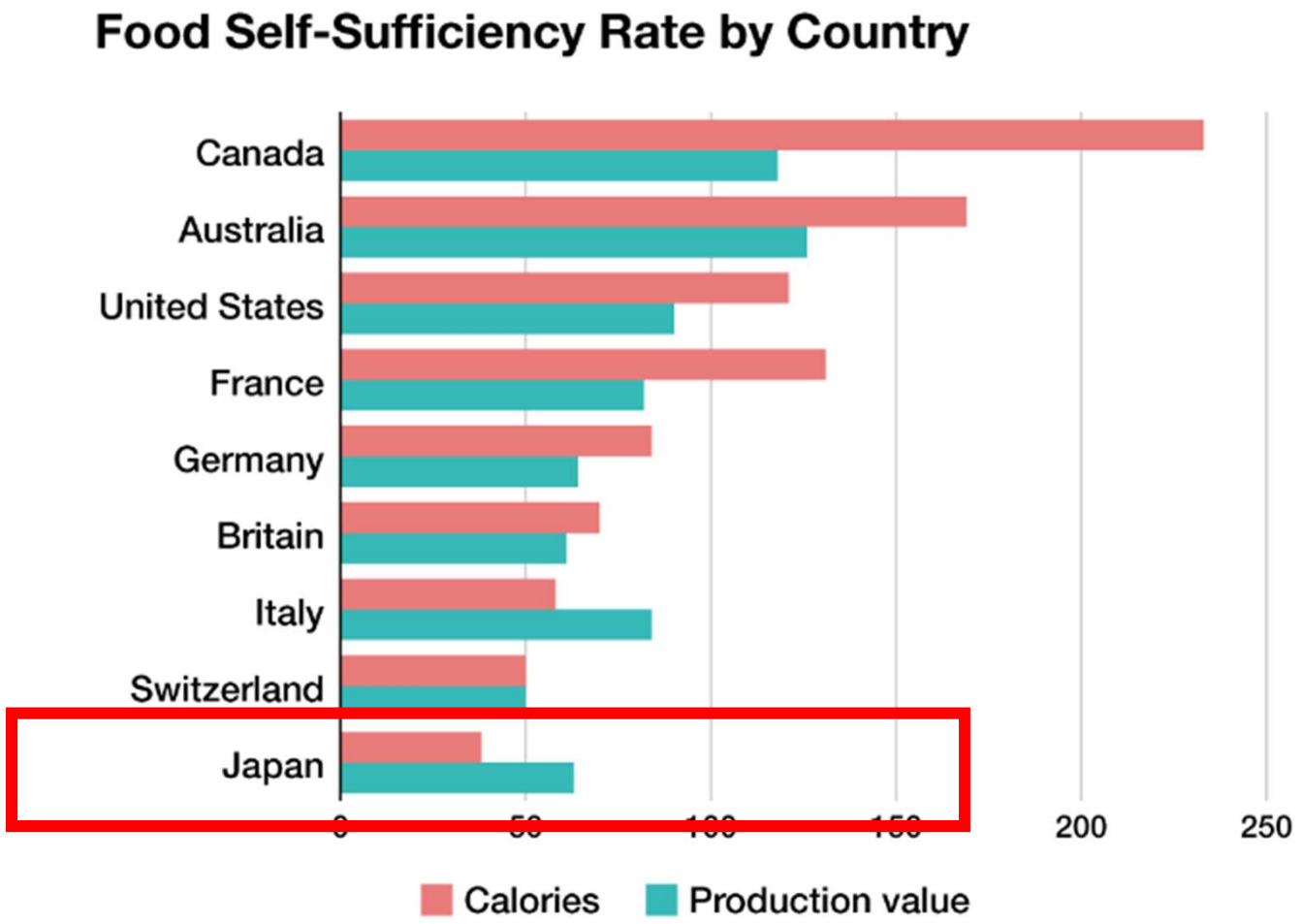
Policy MIX
Green Growth Strategy in Japan

https://www.meti.go.jp/policy/energy_environment/global_warming/azec/2nd_ministerial_meeting/2nd_AZEC_mm_mou_list_en.pdf

Comparisons of primary energy self-sufficiency ratios among major nations (2019)



Source: Estimates for 2019 from IEA "World Energy Balances 2020", except for data for Japan, which are confirmed values of FY 2019, derived from "Comprehensive energy statistics of Japan", Agency for Natural Resources and Energy. ＊ The ranks in the table are those of the 36 OECD member countries.


Food Self-Sufficiency Rate by Country
Canada
Australia
United States
France
Germany
Britain
Italy
Switzerland
Japan
0
50
100
150
200
250
Calories
Production value
Created by Nippon.com based on data from the Ministry of Agriculture, Forestry, and Fisheries.
nippon.com

営農型太陽光発電（Agrivoltaics）

営農型太陽光発電（Agrivoltaics）

営農型太陽光発電（Agrivoltaics）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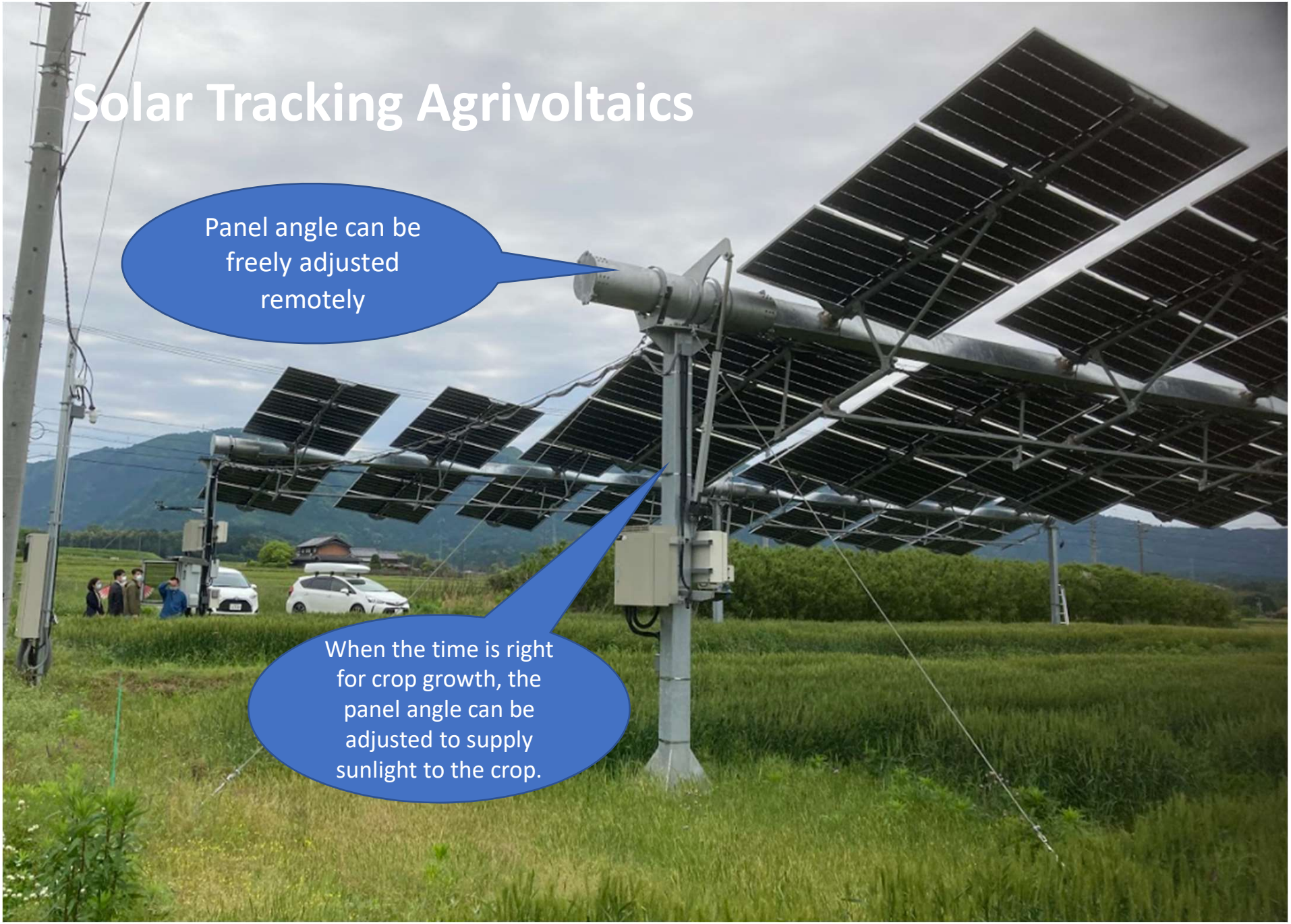

Solar Tracking Agrivoltaics
Panel angle can be freely adjusted remotely
When the time is right for crop growth, the panel angle can be adjusted to supply sunlight to the crop.


D1：Ruethai-san
(タイからの社会人博士)
D1：中田君
代表：尾形

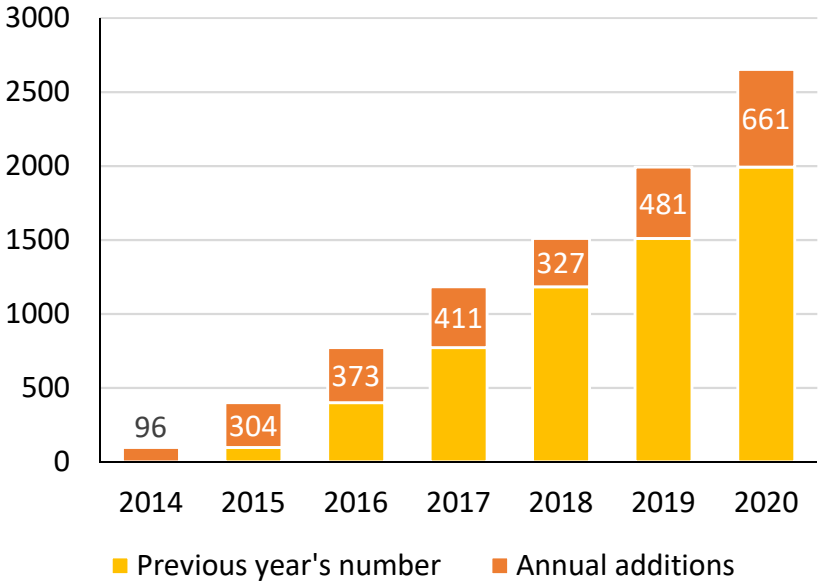
大規模農業向けの営農型太陽光発電

日本では風圧を考慮する必要がある。

Situation of Agrivoltaic in Japan

Japanese government permitted to install PV on the running farm by 2013.

- Ministry of Agriculture, Forestry and Fisheries(MAFF) permits for the installation of Agrivoltaic's facilities have been granted by 2020,2500 cases, 741.6ha
- The crops produced on the farmland under the solar panels vary.



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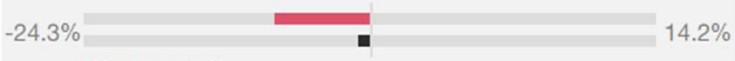
Carbon intensity and Energy intensity
Thai and Japan

Carbon intensity 2023 progress

Japan -8.1%



World -1.0 %

Carbon intensity (tCO_2 / $m GDP) measures the amount of carbon dioxide emitted per million dollars of GDP.

Global annual target: **-20.4%**

Fuel factor 2023 progress

Japan -3.0%

World 0.1 %

Fuel factor (tCO_2 / TJ energy) measures how much CO_2 is emitted per unit of energy consumed. Put simply, how green the energy consumption is.

Global annual target: **-16.9%**

Energy intensity 2023 progress

Japan -5.1%

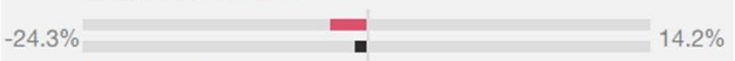
World -0.9 %

Energy intensity (TJ energy / $m GDP) measures the amount of energy consumed per unit of GDP generated.

Global annual target: **-4.2%**

Carbon intensity 2023 progress

Thailand -3.2%



World -1.0 %

Carbon intensity (tCO_2 / $m GDP) measures the amount of carbon dioxide emitted per million dollars of GDP.

Global annual target: **-20.4%**

Fuel factor 2023 progress

Thailand -1.6%

World 0.1 %

Fuel factor (tCO_2 / TJ energy) measures how much CO_2 is emitted per unit of energy consumed. Put simply, how green the energy consumption is.

Global annual target: **-16.9%**

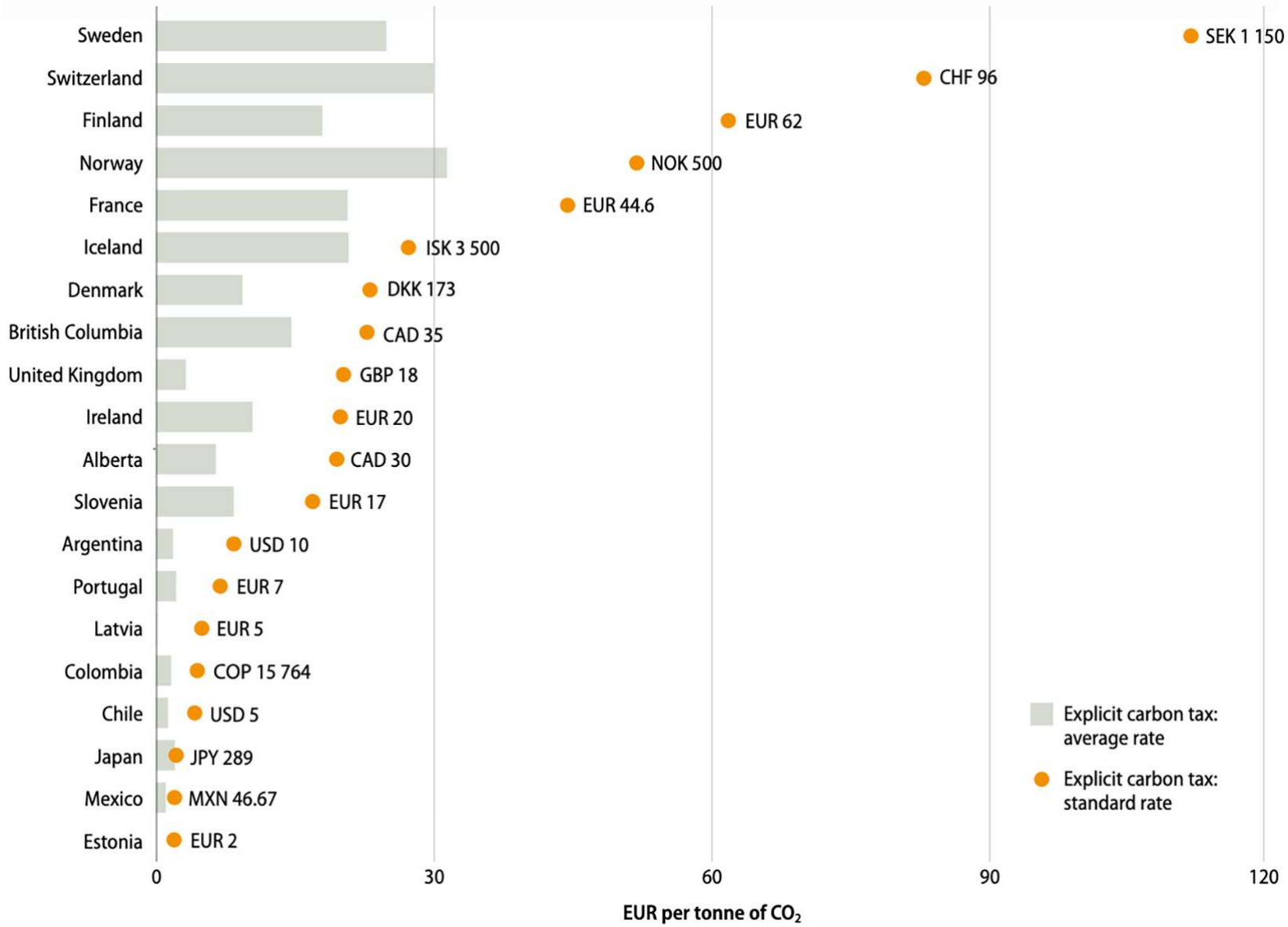
Energy intensity 2023 progress

Thailand -1.7%

World -0.9 %

Energy intensity (TJ energy / $m GDP) measures the amount of energy consumed per unit of GDP generated.

Global annual target: **-4.2%**



https://doi.org/10.1016/j.crsust.2021.100082

Social Cost of Carbon

Prof.Nordhaus(USA) Nobel Prize(2018)

2020: $37.3/tco$_2$

Estimate by USA Government (high Cost Case)

2020: $51/tco$_2$ 2030: $62/tco$_2$

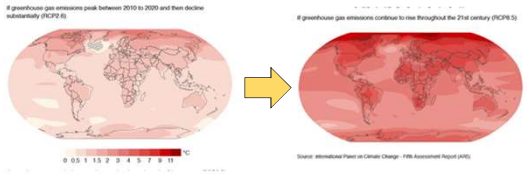
Japan

289Yen/tco$_2$

Challenge to scientific solutions for issues in “Agriculture and Energy Industries” in Japan

Global warming and climate change

COP21 “Paris agreement” in 2015 after
COP3 “Kyoto Protocol” in 1997

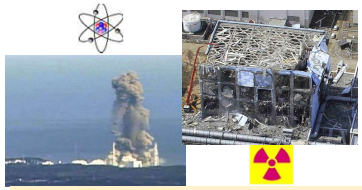


Revitalization of Agriculture Industry and maintaining Food self-sufficiency rate

- Aging farmers and lack of successors
- Small size of average farms (7.4 acers)
- Low level of income of farmers ($30k/yr)
- Strict restriction of converting land use

Sustainable Food and Energy Co-Production

Nuclear disaster in Fukushima and increasing Fossil fuel consumption



140k people evacuated around the Nuclear Plant

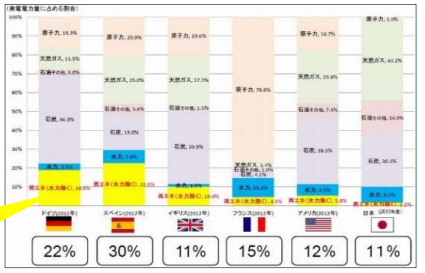
Importing LNG about 2-times 2010 to 15

Low ratio of renewable energy usage compared with other advanced countries

Wind-power

Photovoltaic power

Renewable Energy
(except hydro-generation)

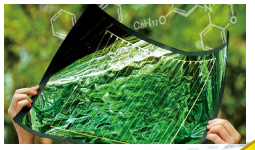


Future Food and Energy System Model Combining Agriculture and Urban Society

Industrial Convergence Food and Energy Co-Production

Solar for ALL

Perovskite Photovoltaic



How to Maximize Solar Light

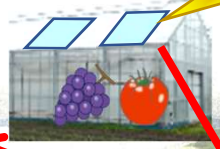
Local production for Local consumption and Selling Electricity to Power Companies

Traditional Energy Sources

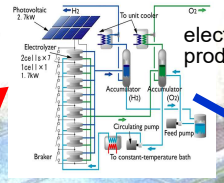
Electricity by Power Company

City Gas

Fossil Fuels



electricity



electrolysis hydrogen production system

Hydrogen(H_2)

Renewable Hydrogen Supply Station

Fuel Cell Vehicles

Electric Vehicle

Smart Grid Management System

Silicon solar cells

Agrivoltaic

battery system

Hydrogen(H_2)

(Night time)

Hydrogen Engine (combined heat & Power)

Industrial Fuel Cell

Electricity Generation

Smart Heat Pump

Air conditioner(heating/cooling)

Collaboration with private companies & local communities

Local production for Local consumption

Supplying
Renewable Electricity・Hydrogen・Hot Water・Agricultural Foods

Business model for Sustainable food value chain

Interdisciplinary Joint Research among Graduate Schools and Institutes

- Energy Science
- Institute for Chemical Research
- Agriculture
- Institute of Advanced Energy
- Informatics
- Economics
- Advanced Integrated Studies in Human Survivability
- Disaster Prevention Research Institute

International Corroboration

- IIT Hyderabad (India)(2023~)
- MTEC (Thailand)(2022~)
- Chiang mai University (Thailand)(2021~
- A University (Indonesia) (2024~)
- B University (China) (2024~)

Research Keywords

Carbon neutral / decarbonized society, Smart and Sustainable Agriculture
Adaptation of Agriculture to Climate Change
Artificial Intelligence in the Energy-Food-Water Model
Smart Grid for Renewable Energy /Peer-to-Peer Energy Trading
Sustainability studies (humanities and social sciences)

Thank you very much
MTEC (TIIS)