脱炭素社会の姿と実現へのシナリオ

Carbon Neutral Society: Vision and Scenarios

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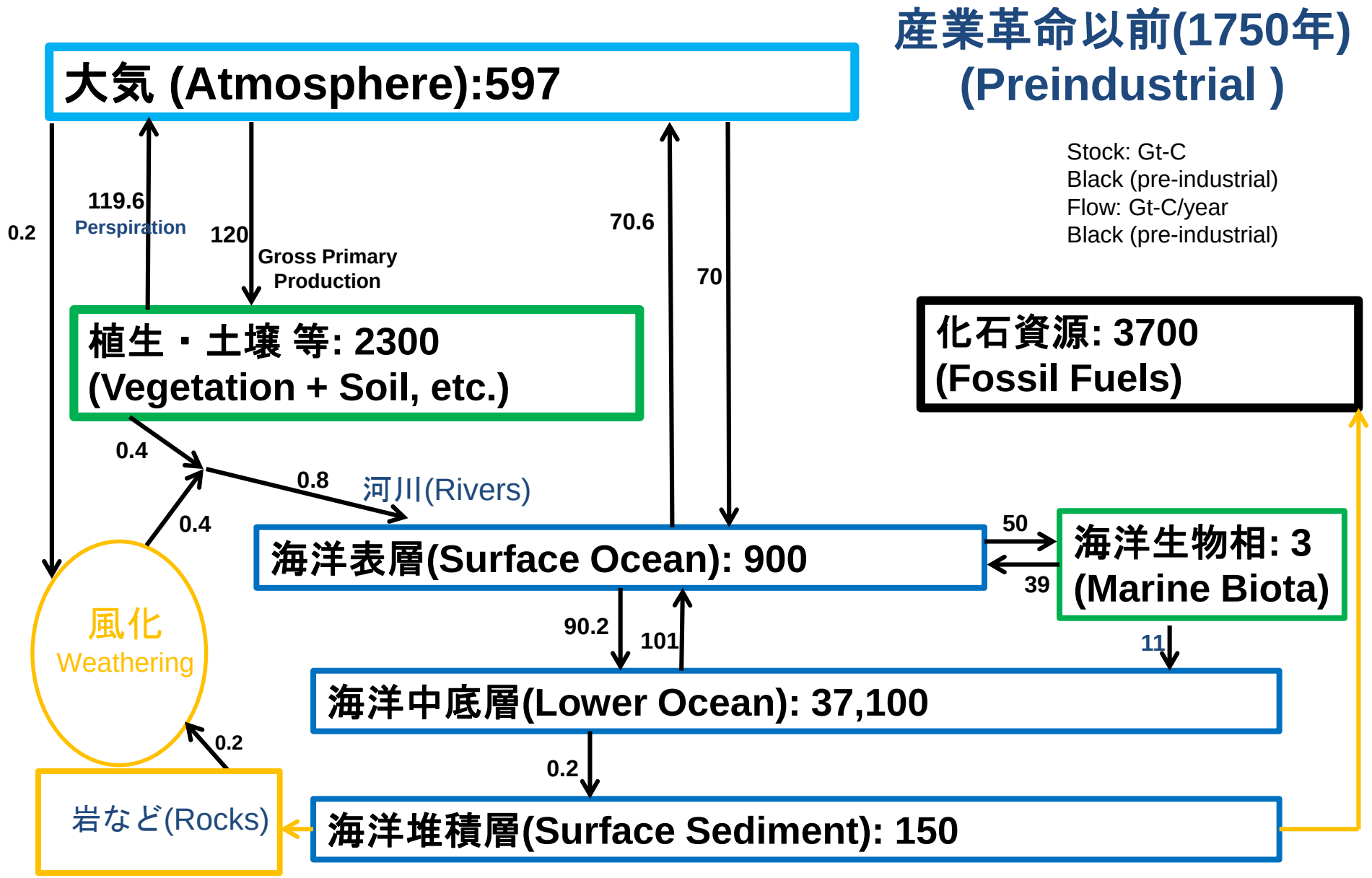
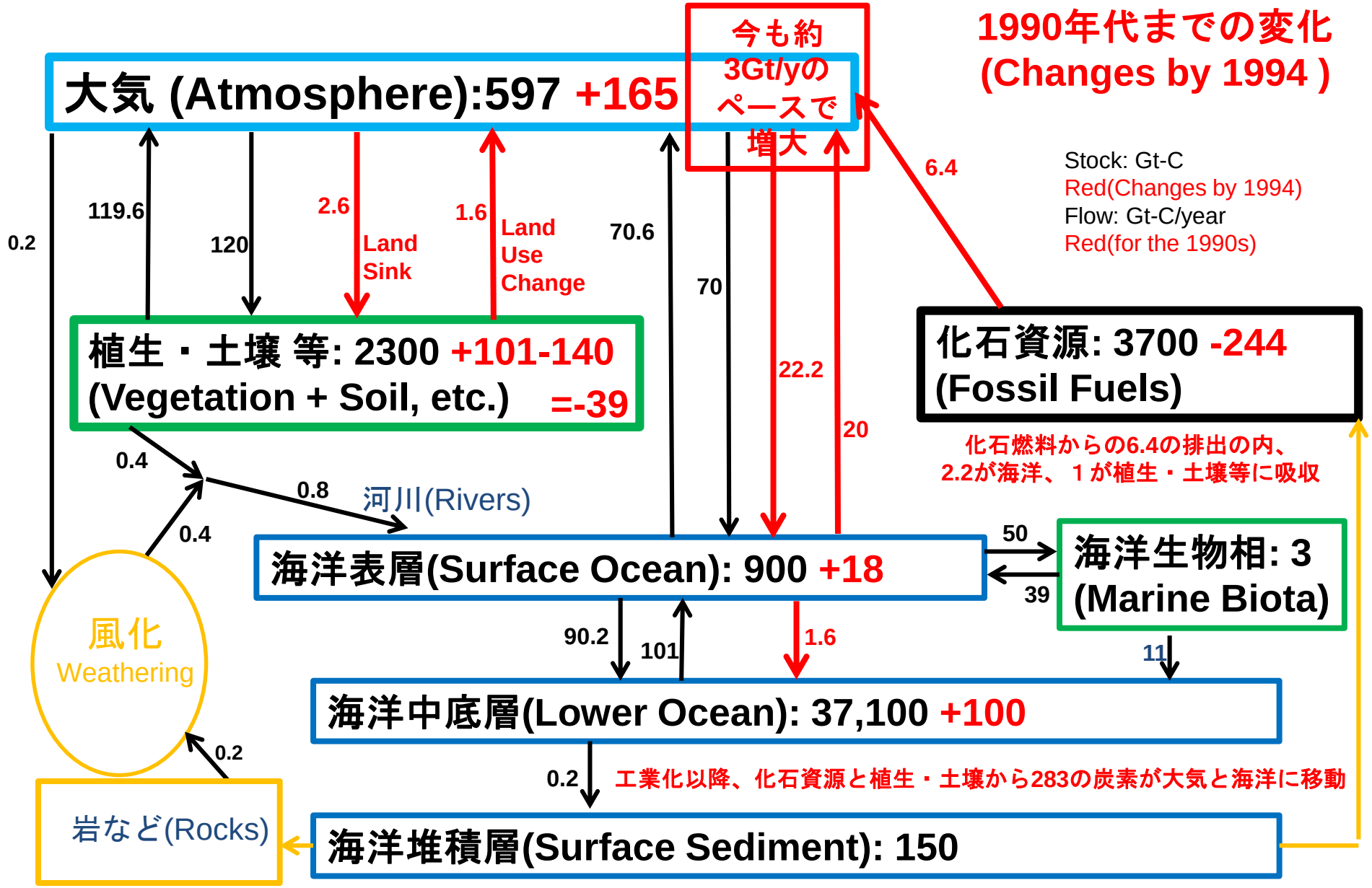
脱炭素社会の姿(Vision of Carbon Neutral Society)



(IPCC AR4 WG1 (2007)のFig 7.3に基づき山地が作成)

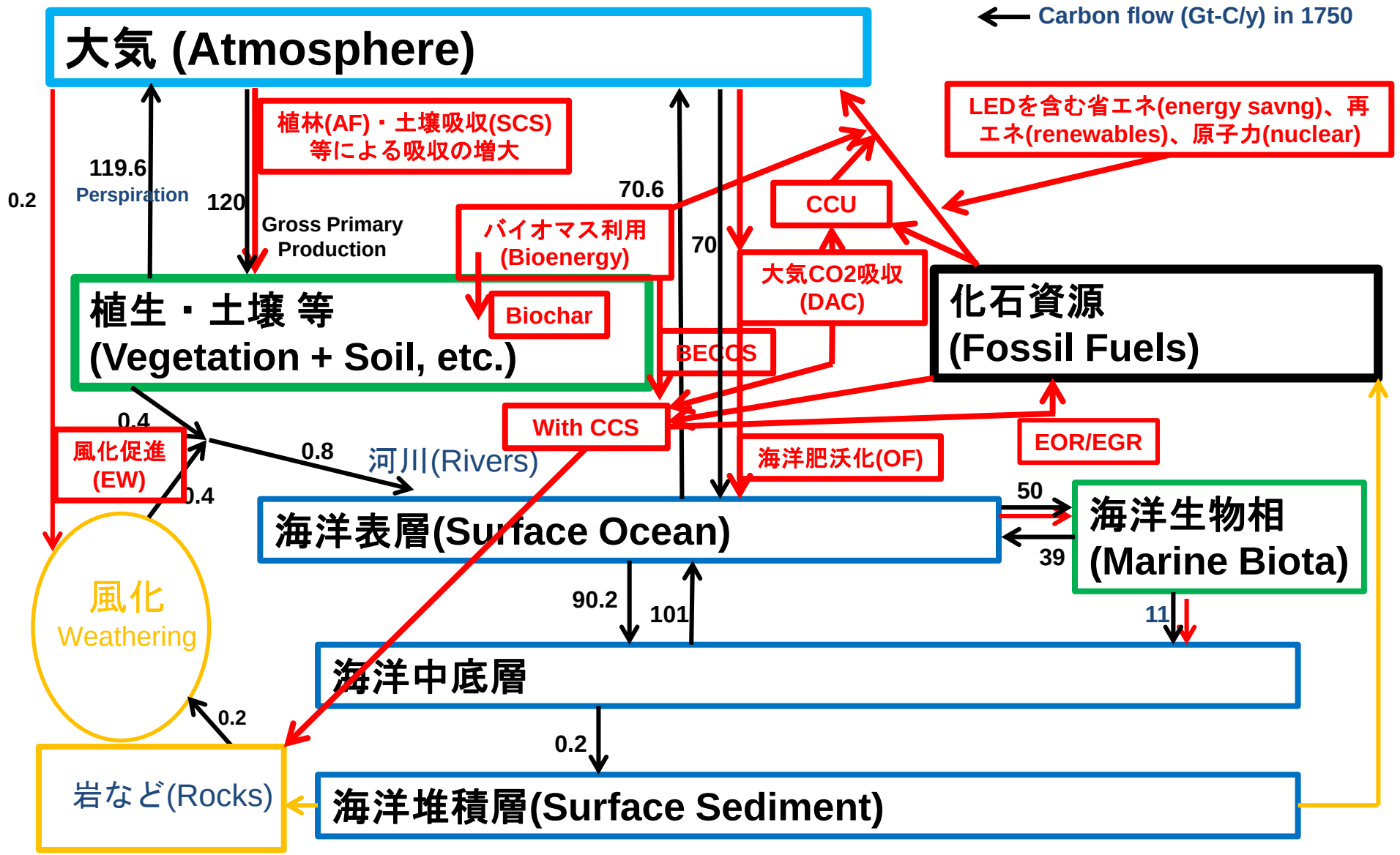
脱炭素社会の姿(Vision of Carbon Neutral Society)



(IPCC AR4 WG1 (2007)のFig 7.3に基づき山地が作成)

脱炭素社会への道筋(Possible Pathways to Carbon Neutrality

大気中GHG濃度の安定化(UNFCCC)→正味排出量ゼロ(脱炭素社会(Carbon Neutrality))



(IPCC AR4 WG1 (2007)のFig 7.3に基づき山地が作成)

Basic Structure of Paris Agreement (PA)

Long-term Global Goal：

- Keeping temperature rises to well below 2℃ relative to pre-industrial levels, pursuing 1.5℃, and
- Achieving net zero GHG emissions (Carbon Neutrality) in the latter half of the 21st century.

Global Stocktake：

- NDCs are to be internationally and comparatively reviewed and evaluated from the viewpoint of meeting long-term targets.

NDC and Long-term Strategy：

- All of the member nations are required to submit their emission targets as the Nationally Determined Contribution (NDC),
- Pledge & Review
- NDCs are updated every five years
- Submit Long-term Strategy toward 2050 by 2020.

COP21(Dec. 2015、PA was adopted)、PA enforced (Nov. 2016)、COP24(Implementation scheme excl. market mkm agreed)、US notified UN of Paris climate accord withdrawal (Nov. 2019)、COP25

Policy of Japan for Innovations in Energy and Environment

Paris Agreement (framework after 2020 covering all major countries) :
Adopt(2015) → Effective(2016) → Implementation scheme(2018；exc. market mkm)

5th Basic Plan for Science and Technology decided in Jan. 2016: proposing Super Smart Society (Society 5.0))

5th Strategic Energy Plan of Japan decided in July, 2018：
Target for 2030 maintained、Vision for 2050 as an ambitious goal

IPCC 1.5℃ Special Report (2018)：net zero emission required in 2050

G20 in Japan (June 2019), Long-term Low Emission Development Strategy was submitted to UN.; G20 Innovation Action Plan in Karuizawa

Sept. 2019: International meetings for Hydrogen and Carbon Recycling

Oct. 2019: Green Innovation Week (TCFD Summit, ICEF, RD20)

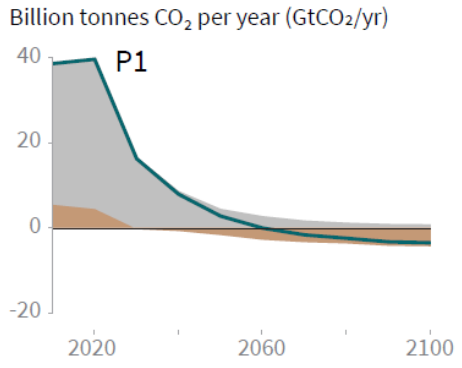
Progressive Environment Innovation Strategy was decided (Jan. 2020)

Coming: Nov. 2020：election of US President、(G7 in the USA)

Categorization of deep emission reduction scenarios for below 1.5 °C

Fossil fuel and industry AFOLU BECCS

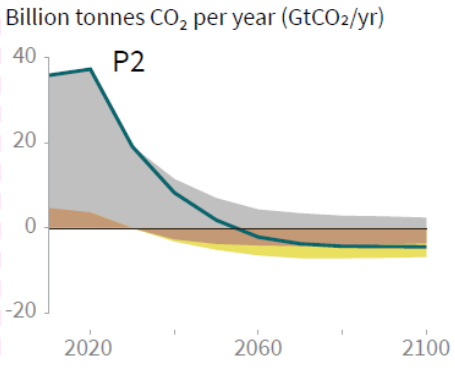
Source) IPCC SR15



P1: A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

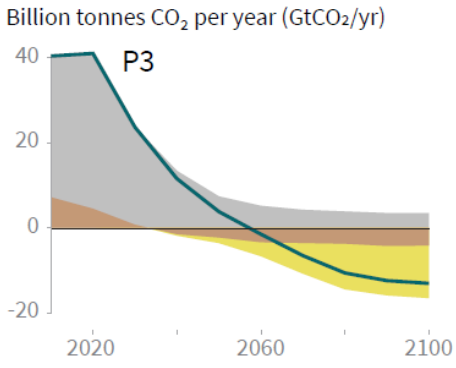
Much lower energy demand scenarios than those of SSP1

- Low energy demand is induced autonomously on economic principle through technological and social innovations
- Low carbon prices (business based measures even without strong climate polices)



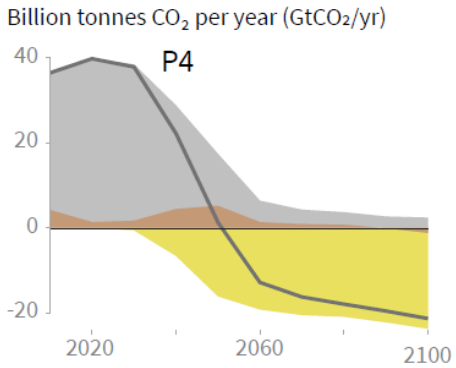
P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

SSP1



P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

SSP2 (Middle scenario)



P4: A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

SSP5

Low ⟷ High

Final energy demands

- ✓ **The total risk management is important, and various kinds of technologies play their own roles.**
- ✓ **On the other hand, opportunities of innovations in end-use technologies, induction of low energy demands, and their impacts on total climate change mitigation should be more focused. (P1)**

- High carbon prices (harmonization among nations are required to avoid carbon leakage)
- Large-scale deployments of CDR, e.g., CCS, BECCS, DACS, are required.

Highlights of Japan's Long-term Strategy under PA

Proclaiming a "decarbonized society" as the ultimate goal and aiming to accomplish it ambitiously as early as possible in the second half of this century, while boldly taking measures towards the reduction of GHGs emissions by 80% by 2050

Chapter 3: Cross-sectoral Measures for Achieving a Virtuous Cycle of Environment and Growth

Section 1: Promotion of Innovation

·Promoting innovation for practical application and wide usage of cross-sectoral decarbonizing technologies leading to drastic reduction of GHG, achieving the cost to enable adoption in the society

(1) Progressive Environment Innovation Strategy

·Setting clear targets such as costs, maximizing provision of provision of the resources from both the public and private sectors, seeking out and creating potential technologies in Japan and abroad, setting challenges based on the needs, strengthening support for making it to the business case

·Challenging R&D, and enhancing alliances among R&D institutes with facilitation of international joint R&D activities [Research and Development 20 for clean energy technologies(RD20)]

·Target setting and visualizing of issues for commercialization

- Realizing hydrogen cost equivalent to existing energy: e.g. lowering manufacturing cost of CO_2-free hydrogen to 1/10
- Realizing products utilizing CCU/Carbon Recycling at the level equivalent to existing products in terms of cost, nuclear power(such as Reactor, Fusion)

(2) Innovation in Economic and Social Systems/lifestyle

Section 2: Promotion of Green Finance

·Appropriately "visualizing" corporate initiatives in innovation and mobilizing finance for innovation by financial institutions

(1) Mobilizing green finance through Disclosure including TCFD※ and dialogue ※Task Force on Climate-related Financial Disclosures

·Industry: Expanding on the TCFD Guidance/Scenario Analysis Guide / Financial sector: Formulating a guidance on green investment

·Creating a venue for dialogue between industries and financial sector (TCFD Consortium)

·Promoting discussion and sharing the above initiatives with the world (TCFD Summit)

(2) Promoting initiatives to expand ESG finance

·Promoting ESG finance (Support to the issuance of green bonds, encouraging local ESG finance), the development of ESG Dialogue Platform, enhancing ESG finance literacy, ESG Finance High-Level Panel

Section 3: Business-led Promotion of International Application, and International Cooperation

·Promoting international application of products and goods with high environmental performance/ promoting co-innovation benefiting participants from both countries

(1) Promoting international application of decarbonizing technologies together with policy and institutional support and rule-making

·Promoting wider application of decarbonizing technologies and reductions of GHG emissions through improving business environment by working for institutional development in partner countries and leading international rule-making (e.g. establishing public and private-sector initiatives in ASEAN, and creating appropriate international frameworks for using market-based mechanisms)

(2) Strengthening Development and Investment of infrastructure contributes to reduction of CO_2 emissions

·Promoting development and investment of energy and urban/transport infrastructure abroad in order to contribute to the global reduction of CO2 emissions consistent with the long-term goals stipulated in the Paris Agreement (e.g. renewable energy such as offshore wind power and geothermal power, hydrogen, CCS&CCU, Carbon Recycling, smart cities)

(3) Building basis for decarbonized society on a global scale

·Supporting partner countries in the formulation of NDCs and mitigation plan, enhancing transparency in the entire supply chain

Outline Of Progressive Environment Innovation Strategy (Jan. 2020)

イノベーション・アクションプラン (Action Plan)

－革新的技術の2050年までの確立を目指す具体的な行動計画（５分野16課題）－

①コスト目標、世界の削減量、②開発内容、③実施体制、④基礎から実証までの工程を明記。

(16 Themes in 5 Fields)

強力に後押し

(Acceleration Plan)

アクセラレーションプラン －イノベーション・アクションプランの実現を加速するための３本の柱－

①司令塔による計画的推進

【グリーンイノベーション戦略推進会議】府省横断で、基礎～実装まで長期に推進。既存プロジェクトの総点検、最新知見でアクションプラン改訂。

②国内外の叡智の結集

【ゼロエミ国際共同研究センター等】G20研究者12万人をつなぐ「ゼロエミッション国際共同研究センター」、産学が共創する「次世代エネルギー基盤研究拠点」、「カーボンリサイクル実証研究拠点」の創設。「東京湾岸イノベーションエリア」を構築し、産学官連携強化。

【ゼロエミクリエイターズ500】若手研究者の集中支援。

【有望技術の支援強化】「先導研究」、「ムーンショット型研究開発制度」の活用、「地域循環共生圏」の構築。

③民間投資の増大

【グリーン・ファイナンス推進】TCFD提言に基づく企業の情報発信、金融界との対話等の推進。

【ゼロエミ・チャレンジ】優良プロジェクトの表彰・情報開示により、投資家の企業情報へのアクセス向上。

【ゼロエミッションベンチャー支援】研究開発型ベンチャーへのVC投資拡大。

(Zero Emission Initiatives)

ゼロエミッション・イニシアティブズ －国際会議等を通じ、世界との共創のために発信－

グリーンイノベーション・サミット、RD20、ICEF、TCFDサミット、水素閣僚会議、カーボンリサイクル産学官国際会議

●Innovations in Progressive Environment Innovation Strategy (Yamaji's Understanding for the System of Innovations)

Energy Conversion :
Renewables
Flexible Power NW
Hydrogen Supply Chain
Innovative Nuclear Tech.
Low Cost CO2 Capture
⇒CCUS

Industry :
Free from Fossil Resources
Electrification
CO_2 Recycling

Agriculture and Others :
Reduction of Methane・N_2O
Increase in Sink (Soil/Forest、Blue Carbon)
Smart Agriculture

Transport :
Diversified Green Mobility

Building :
More Energy Conservation
Smart City
Social Innovation (Sharing, Tele work, etc.)

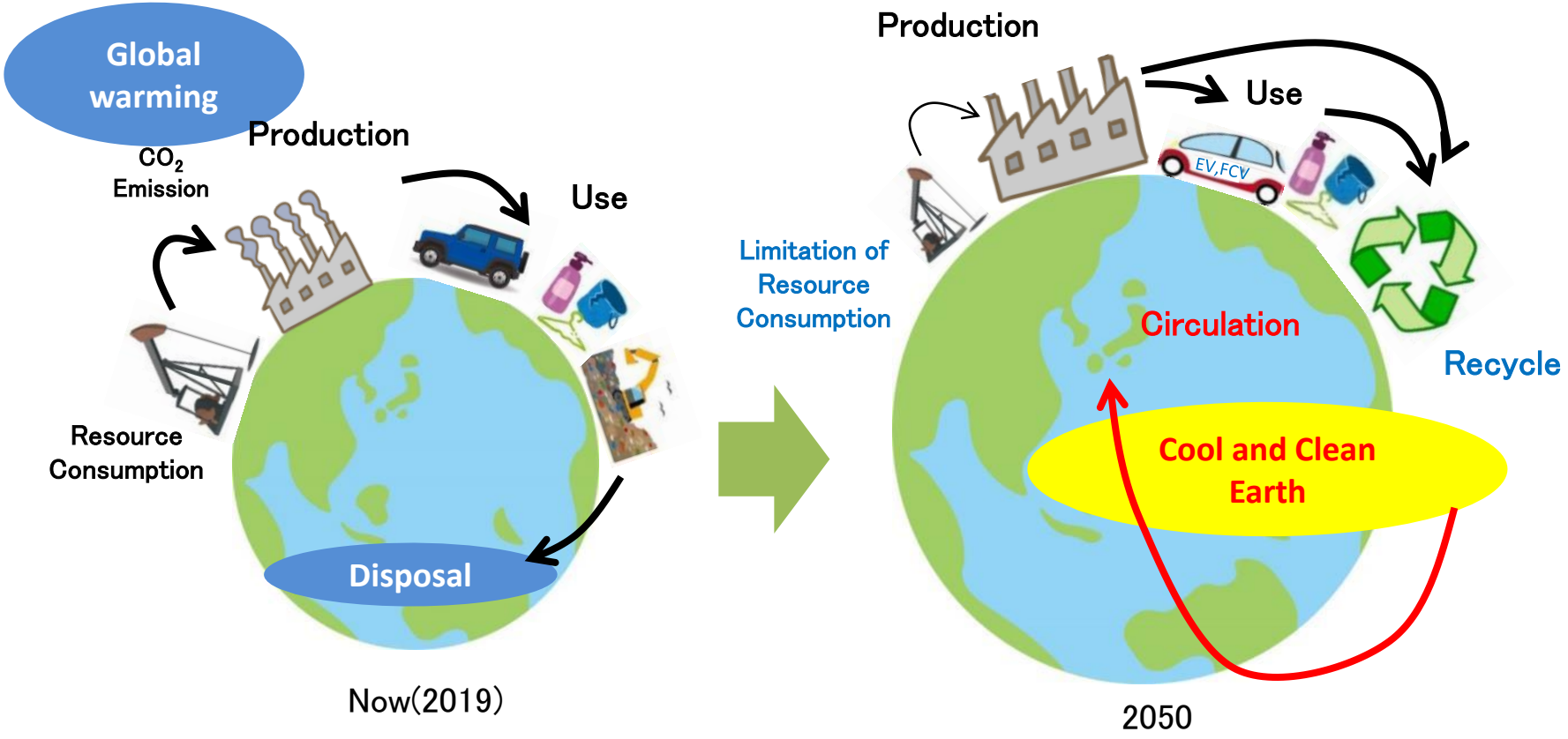
DAC

General Purpose Tech. :
Digital Tech. (Big Data、AI、Blockchain、・・・)
Power Electronics、Material、Energy Storage、Sensing、Biotech.、etc.

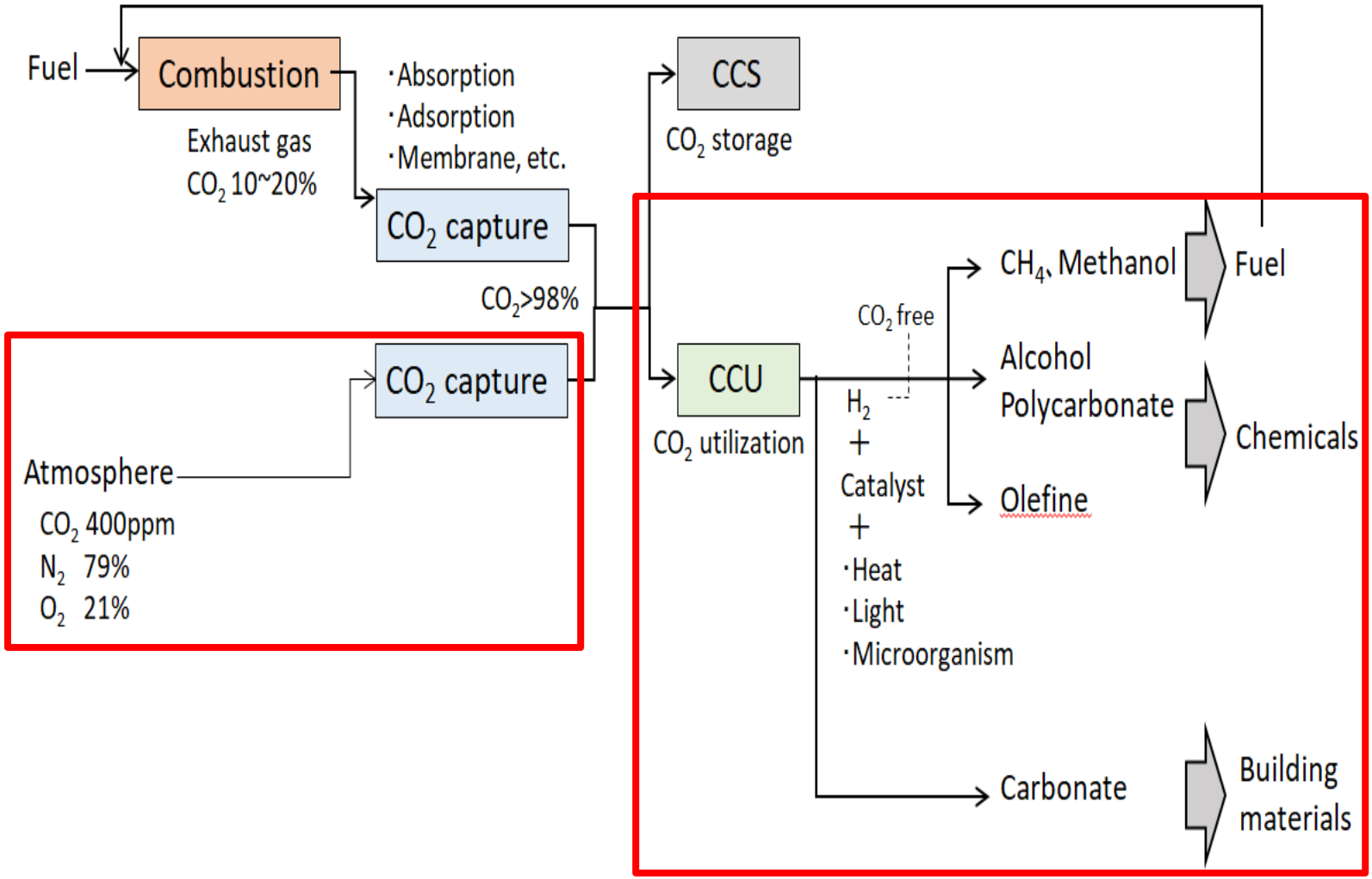
Moonshot Goal No. 4:

Realization of Sustainable Resources Circulation to Recover the Global Environment by 2050

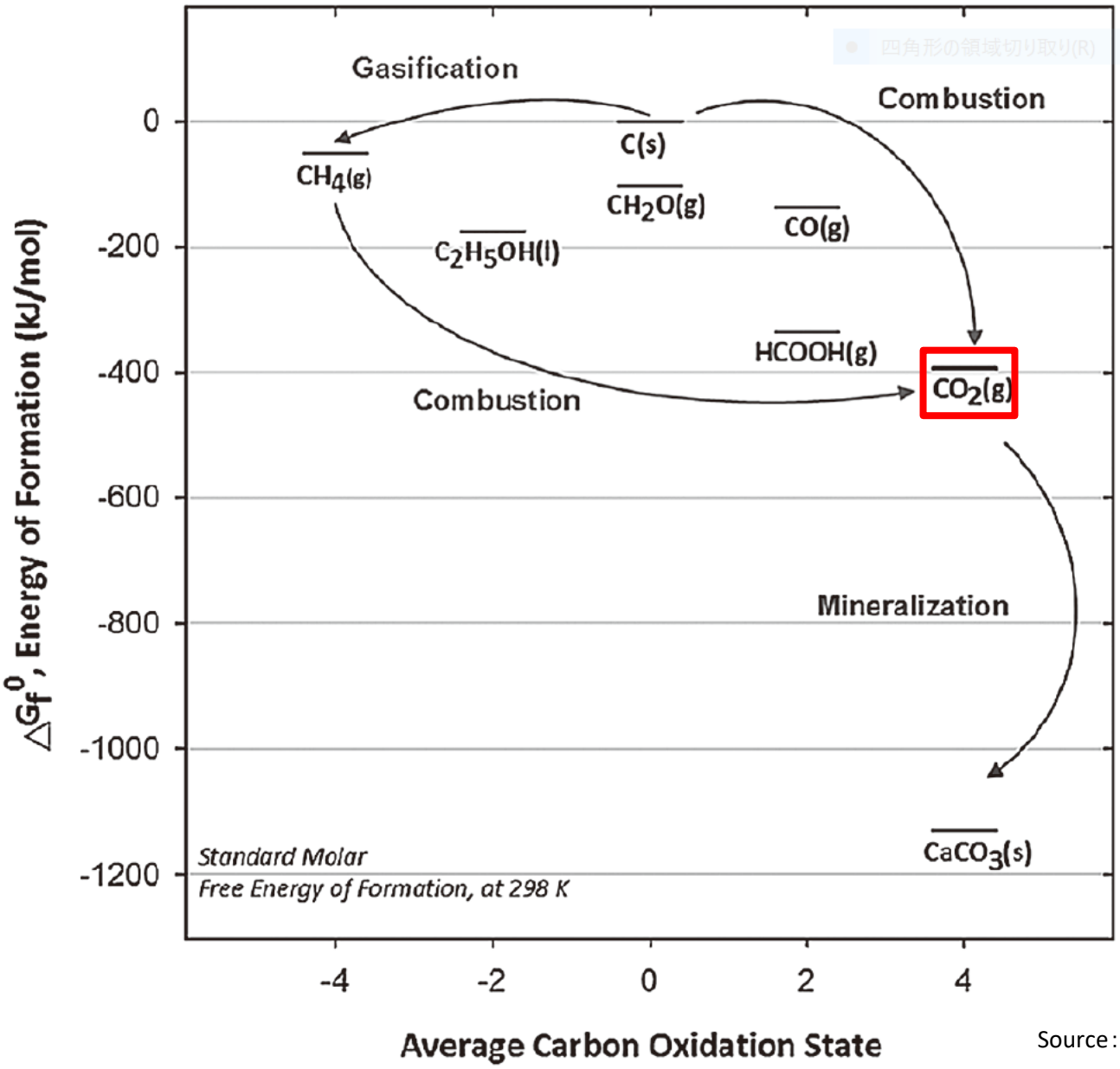
The mission of this Moonshot Goal Candidate is to develop technology for reducing the emissions of greenhouse gases and pollutants to contribute to the recovery from the on-going issues of global warming and environmental pollution. The concept of the this theme consists of two pillars of **"Cool Earth"** and **"Clean Earth"**



Challenge: CO_2 recovery from atmosphere (DAC), and Recovered CO_2 can be converted into fuel and/or various chemicals as a raw material (CCU)



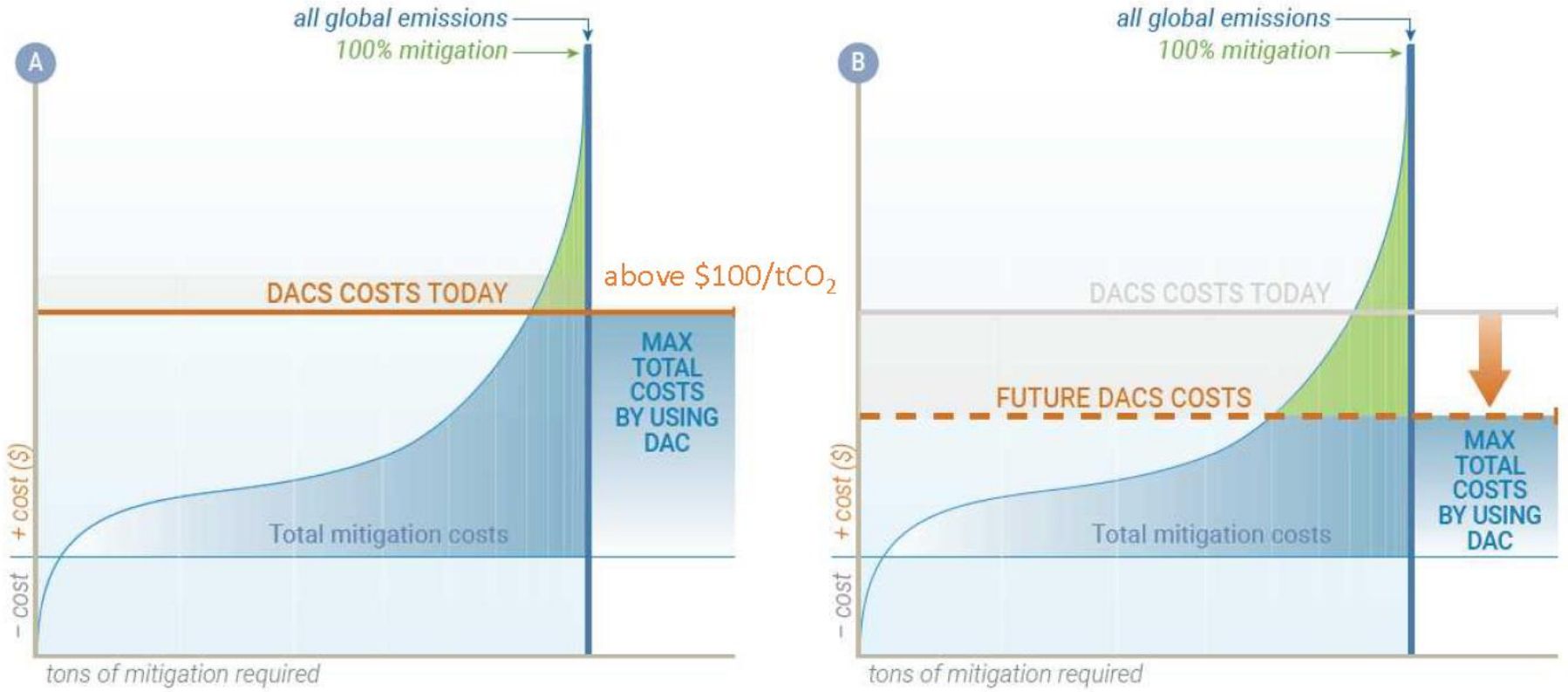
Challenge to Use CO_2 (chemically stable material)



Source：Sakai、Applied Energy、Oct. 2019

Gibbs free energy level of Carbon Compounds

Cost for CO2 Removal (DAC as a Backstop Technology)

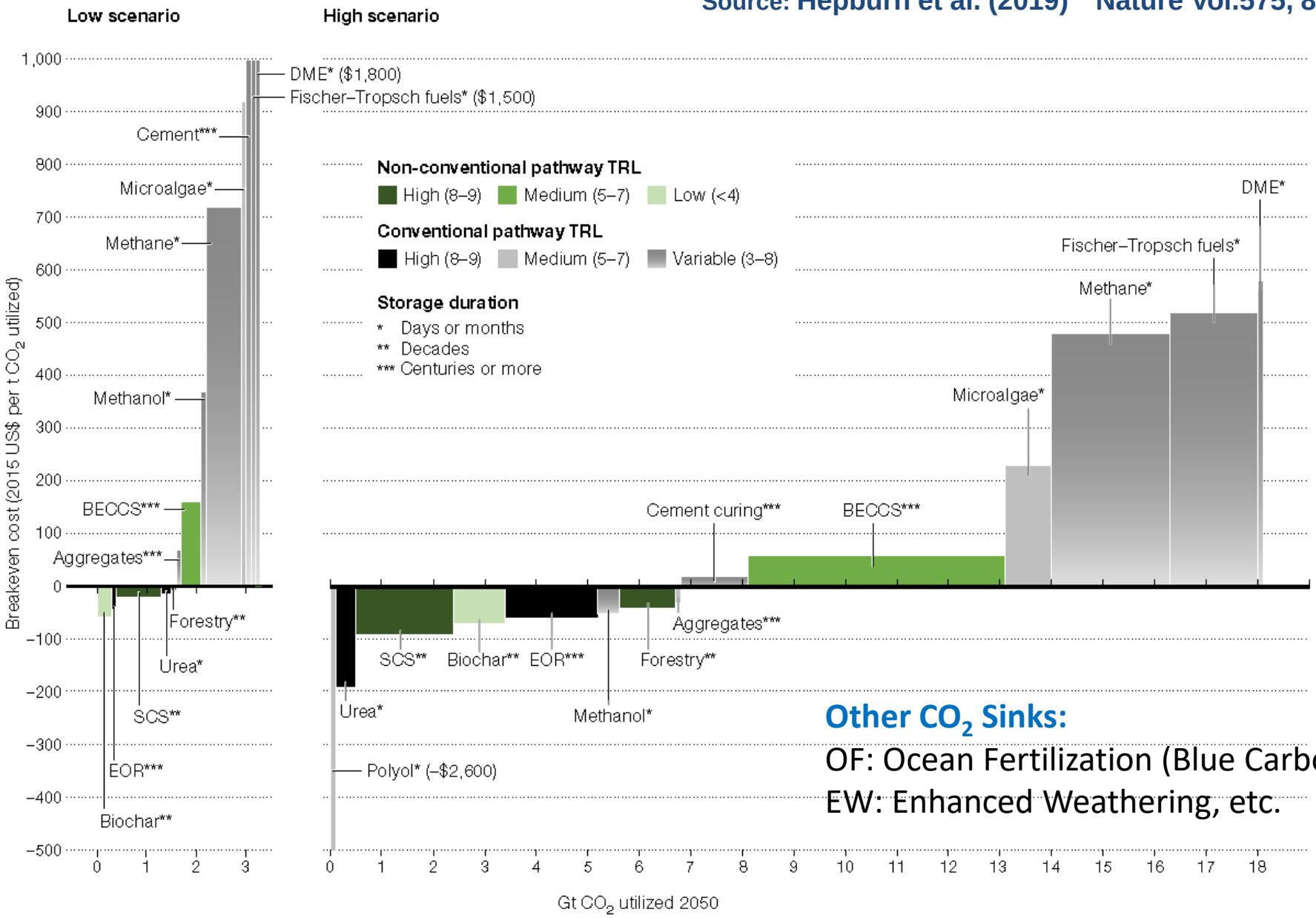


Relationship between cost and introduction amount of DAC

Source: Direct Air Capture of Carbon Dioxide Roadmap (ICEF 2018)

Estimated Supply Curve for CCU

Source: Hepburn et al. (2019) Nature Vol.575, 87-97



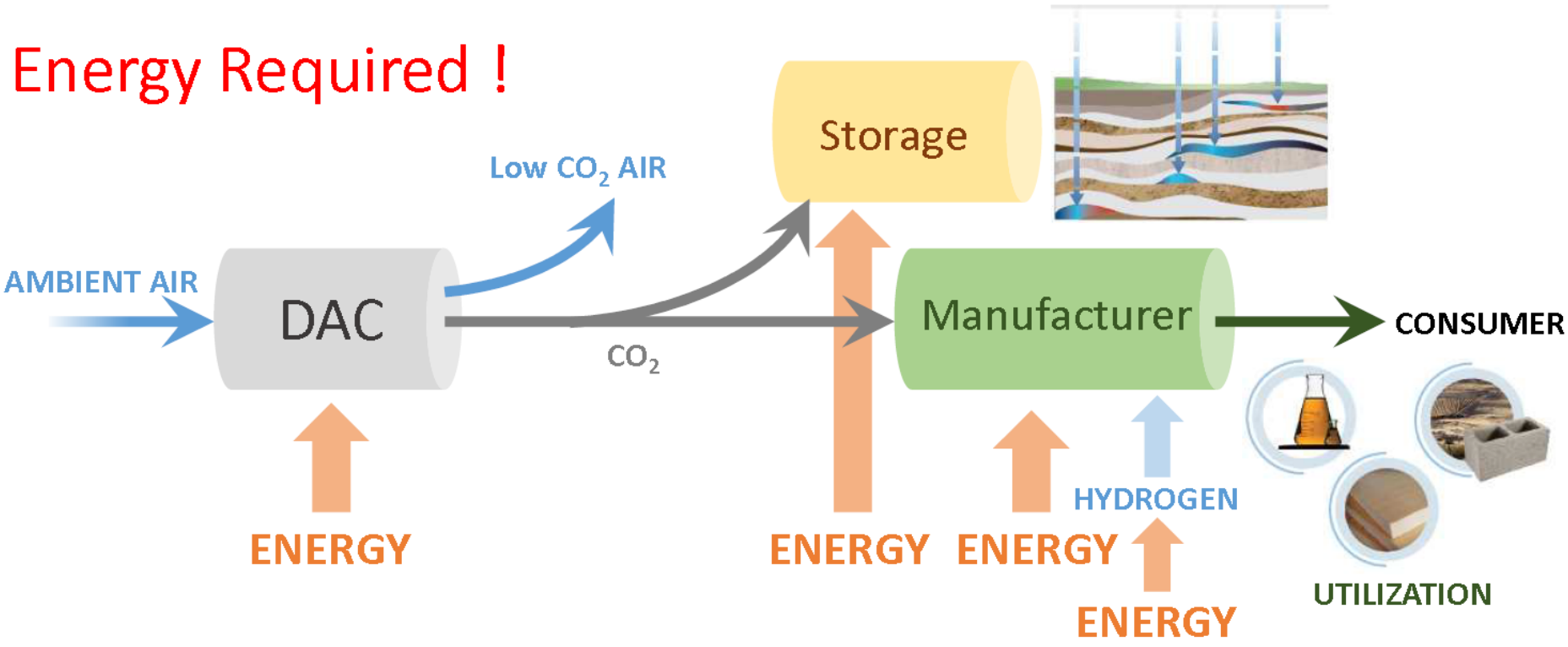
Other CO_2 Sinks:

OF: Ocean Fertilization (Blue Carbon)

EW: Enhanced Weathering, etc.

Direct Air Capture + CO_2 Utilization/CO_2 Storage

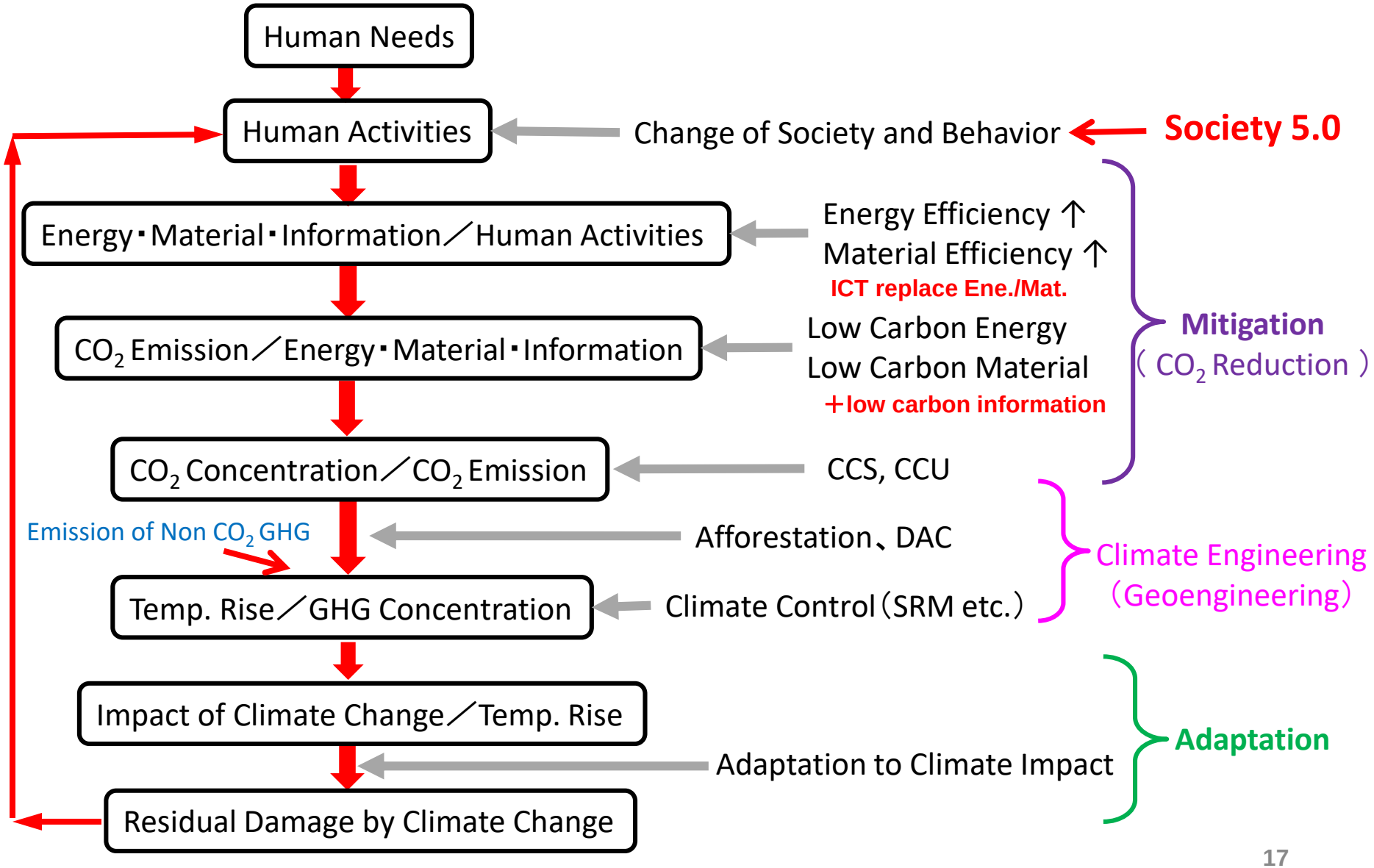
Energy Required !



Energy resource should be zero/low CO_2 emission

(Source: Atsushi INABA, How to evaluate technologies?, Moonshot International Symposium, Dec. 18, 2019)

Structure of Climate Change Response



Source：Kenji Yamaji, 2006：「Theory of 3E Systems Analysis」, Iwanami-Shoten (in Japanese) + modifications by KY

A Vision of Society 5.0 ("Super Smart Society) presented in the 5th Science and Technology Basic Plan in January 2016

Realizing "Society 5.0" ("Super Smart Society")

Around the world, initiatives that use networks and the Internet of Things (IoT), centered on manufacturing fields, are now coming out. In Japan, the use of such networking will not be limited to manufacturing. Instead, it will be extended to various other fields in order to promote economic growth, the formation of a healthy and long-living society, and social transformation. In addition, it will help the fruits of science and technology to penetrate into all kinds of fields and spheres, and thereby lead to enhanced business capability and higher quality services.

We will share our vision of the future, which is characterized by the sophisticated integration of cyberspace with physical space ("the real world") and work to enhance it, while further pursuing a series of measures aimed at its realization, under the concept of "Society 5.0".*

* The history of humankind reveals that the evolution of human society has been fueled by technological advances, with key steps along the way as a hunter-gatherer society, agrarian society, industrial society, and, today, an information society. "Society 5.0" is next, and we'll achieve it by mobilizing the full power of STI.

It is necessary to aim at "systemization" of services and businesses, system advancement, and coordination between multiple systems. Therefore, we will promote the measures needed to develop a common platform for this goal (called "Society 5.0 Service Platform"), through collaboration between industry, academia, and government and the relevant government ministries.

Impacts of "Super Smart Society" (Society 5.0)

Society 5.0 is characterized by the sophisticated integration of cyberspace with physical space ("the real world")

Society 5.0 is capable of providing the **necessary goods and services to the people who need them at the required time and in just the right amount**; a society that is able to respond precisely to a wide variety of social needs; a society in which all kinds of people can readily obtain high-quality services, overcome differences of age, gender, region, and language, and live vigorous and comfortable lives.

Beyond energy saving, Society 5.0 promotes sharing economy to shift the industry from manufacturing to service providers leading to a ultimate circular society.

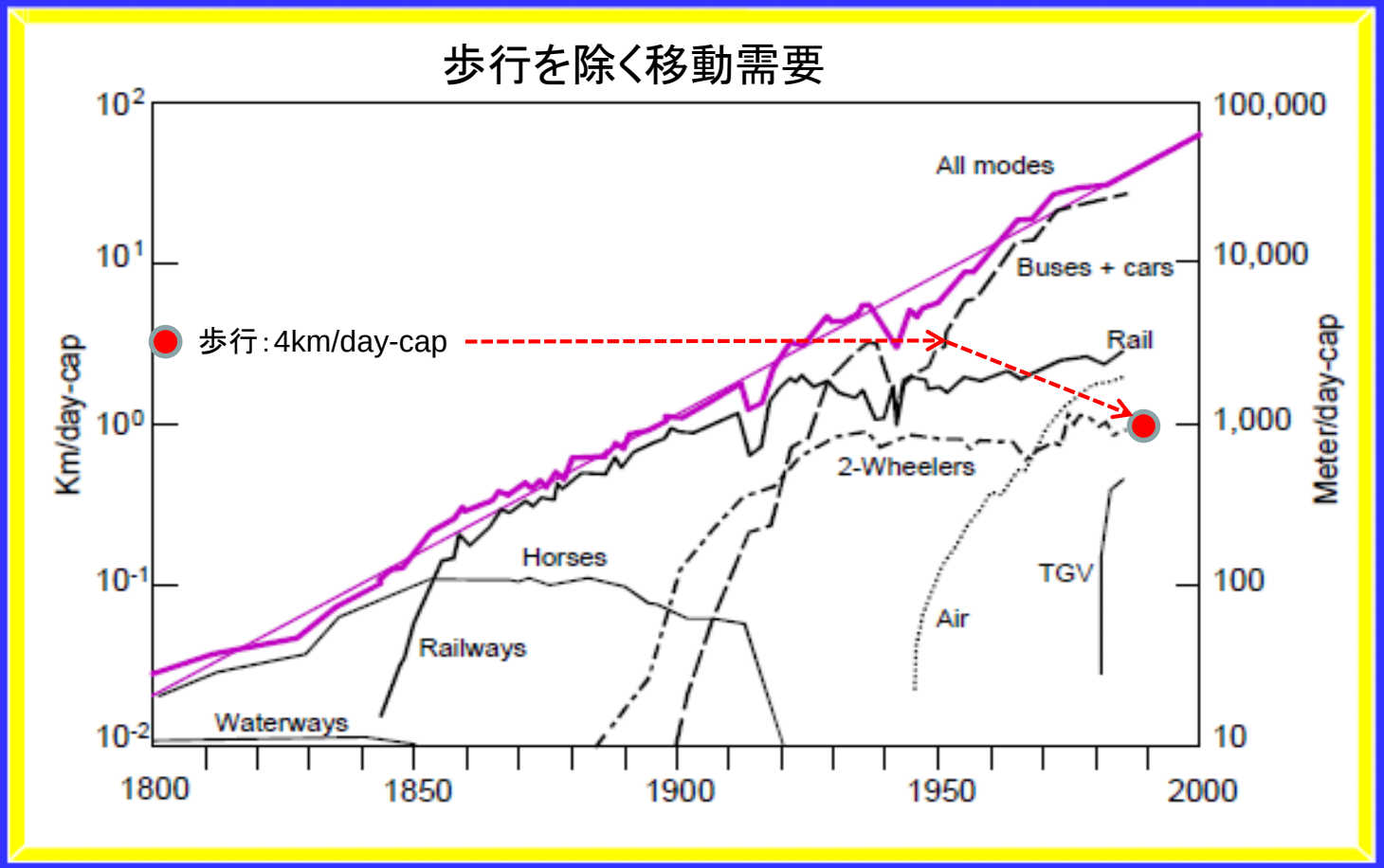
Information replaces Material

Care for Rebound Effects

1) car/ride share → car ↓ → car productions ↓ → material needs ↓ → energy/CO_2 ↓
2) smart maintenance → component replace↓ → material needs ↓ → energy/CO_2 ↓
3) IC tag for all component → recycling rate ↑ → material needs ↓ → energy/CO_2 ↓

Possible huge rebounds by Innovation

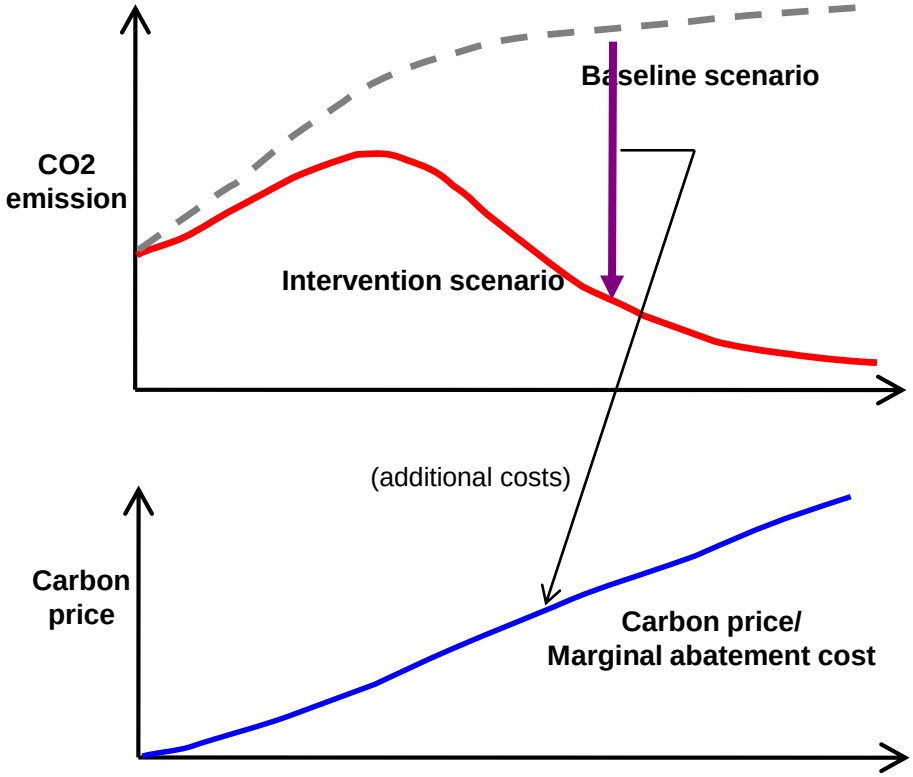
France – Mobility by Travel Mode
(passenger-kilometers per day per person)



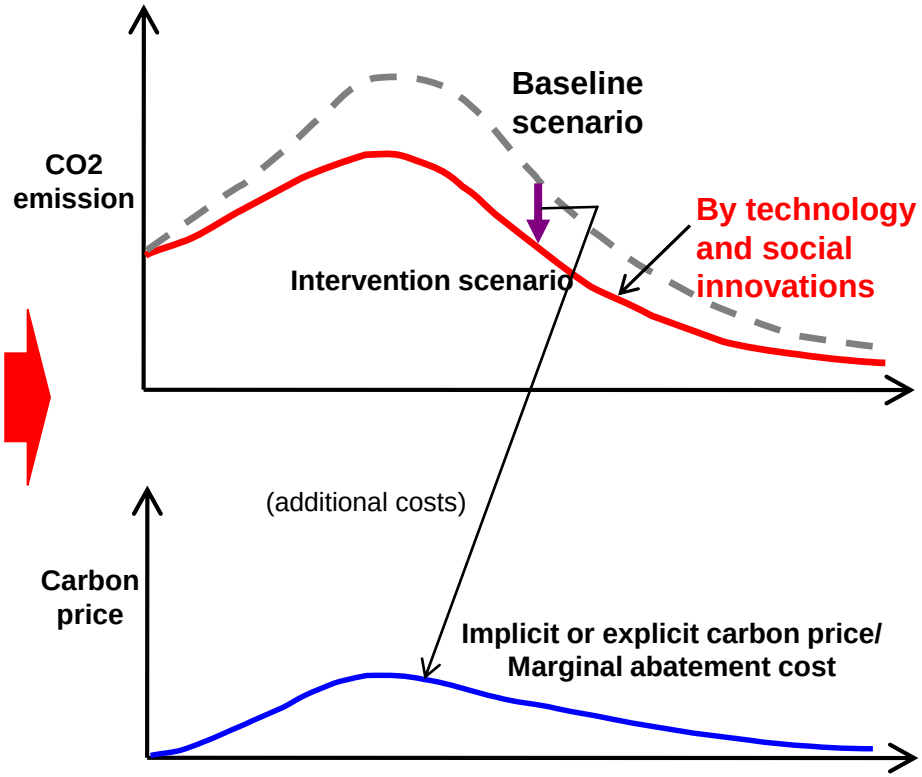
Nakicenovic Source: Grübler, 1998 #7 TU VIENNA IIASA 2006

Image of standard scenarios by models and scenarios required for deep cuts in a real world

Model world: Ordinary technology progress



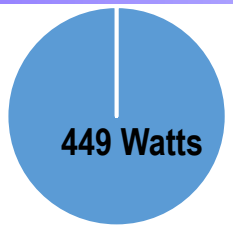
Realistic world requirement: Innovations stimulated & implemented



High carbon prices of over 100$/tCO2 in real price are unlikely to be accepted globally in a real world. Technology and social innovations which will bring low (implicit or explicit) carbon prices (including coordination of secondary energy prices) are key to achieve deep emission cuts.

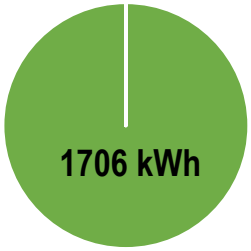
Innovations in end-use technologies through IT and AI, and the induced social changes

Source : IIASA



Power

Stand-by energy use

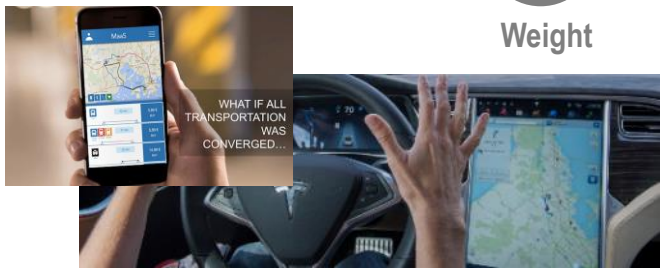


Embodied energy

Weight

- **Energy consumption is not our purpose, but is just a phenomenon accompanying with consumption of goods and services, which is conducted for our welfare increase. Energy embodied in goods and services must be taken into account.**
- **The end-use products and services will usually diffuse rapidly, and the embodied energy and CO_2 may decrease rapidly.**

Operation ratio of automobiles is about 5%. The large room for the improvement exists by the achievement of fully autonomous cars.



There are large opportunities to achieve social changes and to increase energy efficiency through fully autonomous cars, food systems, etc. which can be induced by innovations of IoT, AI etc.

Pathways to Net Zero Emission

Super Smart Society (Society 5.0)

IoT, AI, Big Data, Blockchain, Smart Sensor, …

Integration of Energy and ICT

Mobilize demand side

DR, V2G, VPP, etc.

Social system reform: material producer → service provider, etc.

→ utilization rate up, recycle up, longer life, etc.

Reduced material demands, Behavior change, etc.

Revolutionary Energy Saving through Electrification and Digitalization of Energy

(EV, PHEV, FCV, Heat Pump, …..)

decarbonize industrial heat

Carbon Free Power Source:

Renewables, Nuclear,

Fossil Fuel with CCS

Energy Storage

Battery, PtX…

Clean and Efficient Energy Carrier

(Electricity, Hydrogen etc.)

new power network

Carbon Free Fuel:

Biomass, Fossil Fuel with CCS, etc.

Carbon Free Heat Source:

Solar Heat, Geothermal, etc.

Power sector will be requested to be negative emission in Global Net Zero Emission Scenarios:

BECCS(Bioenergy+CCS) should be comparatively evaluated with other options such as afforestation, CO_2 use, geoengineering (DAC, (SRM) …), etc.

+ Adaptation

SDGs

Keep Options as Many as Possible!


ご清聴ありがとうございました
Thanks for your attention