Life cycle thinking of renewable carbon sources in Japan

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Scenario analysis of future society

The Paris Agreement (2015) ~2030

Zero Carbon Declaration
Climate Emergency Declaration

Sustainable Development Goals (2015) ~2030

Circular Economy

Bioeconomy

within Planetary boundary

Society 5.0 (2016~)

Regional Circular and Ecological Sphere (2018~)

Forecasting

Scenario analysis

Backcasting

- Forecasting scenario
  - Solving current issues
- Backcasting scenario
  - Chasing the visions

Vision

- Sustainable
- Recycle-based
- Carbon neutral
- Circular economy
- Nature positive

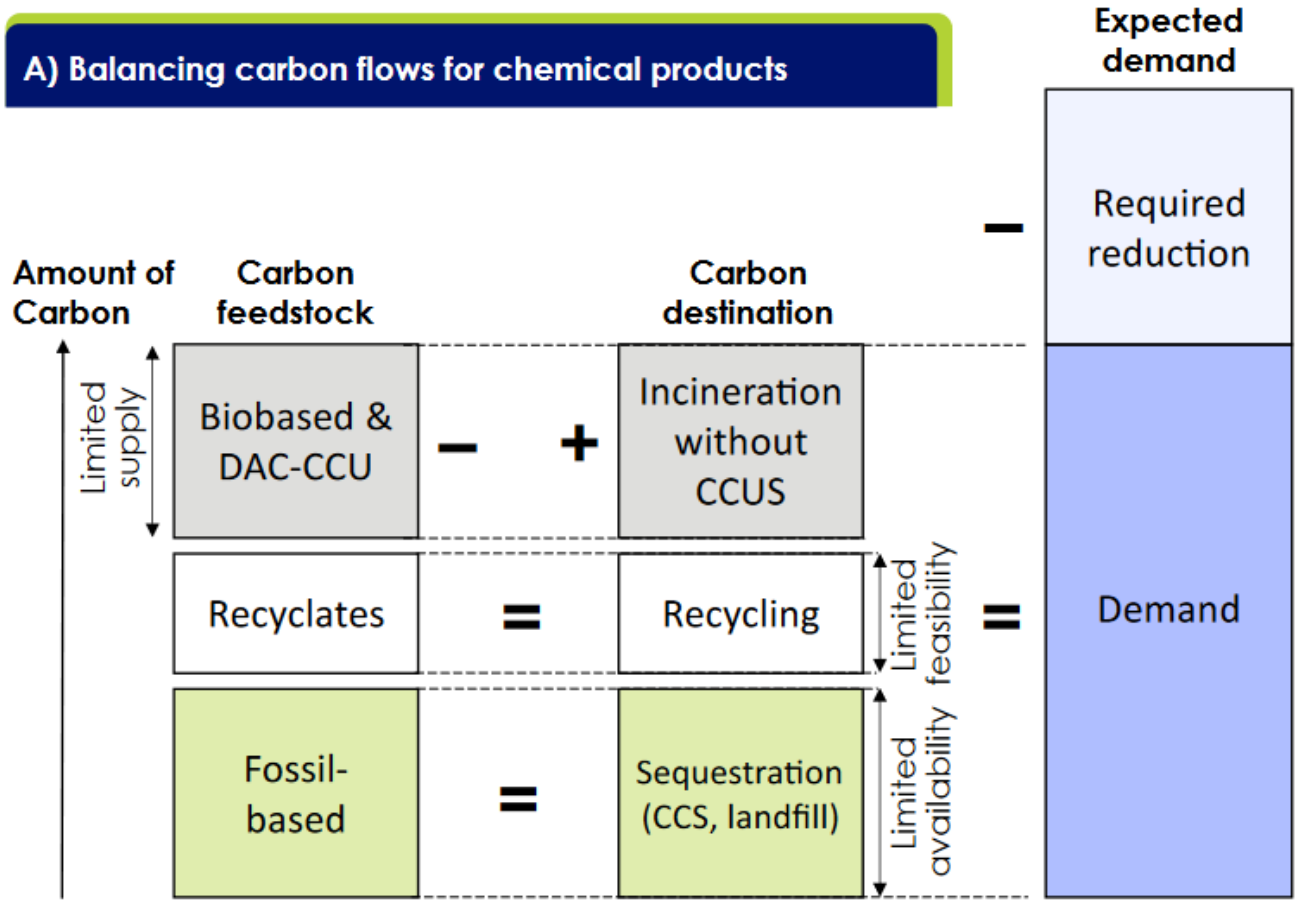
2020 2030 2040 2050

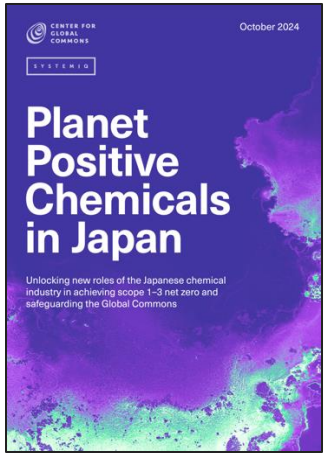
Short term Mid term Long term Ultra long term

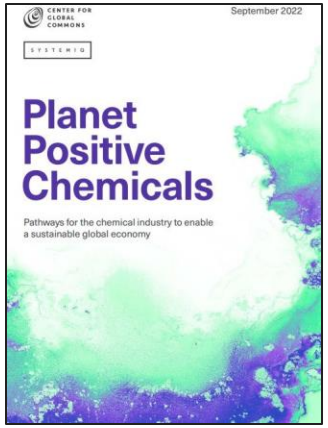
Necessity of life cycle thinking (LCT) for transition

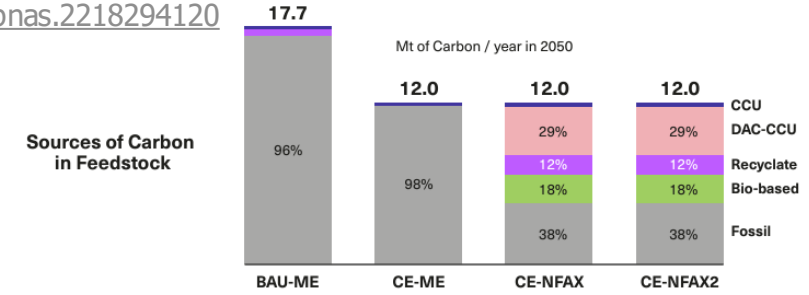
https://doi.org/10.1073/pnas.2218294120

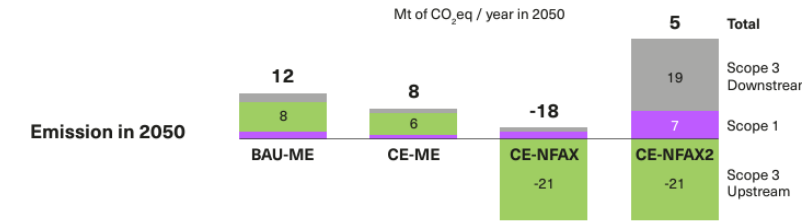
Carbon neutral scenarios for chemical industries



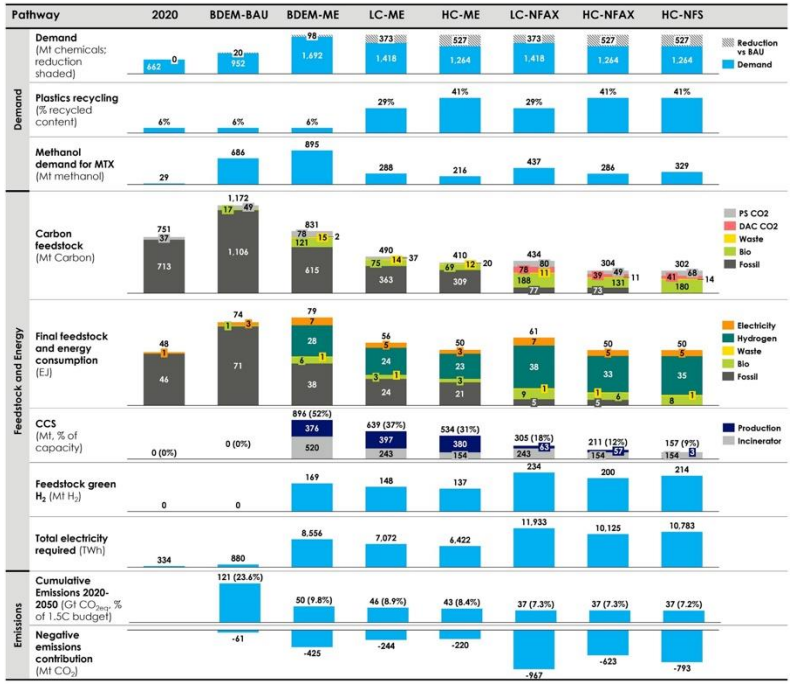








Amount of CCS in 2050	Mt of CO_2 stored / year in 2050			
CCS from Production	13	8	5	0
CCS from Incinerator	34	18	18	0
Total CCS	**47**	**26**	**23**	**0**



BAU/BDEM: Business As Usual in supply/demand
ME: Most Economic
NFAX: No fossil new-build after 2030
NFS: No fossil strict
HC/LC: High/Low circularity

What is Life Cycle Assessment (LCA)?

LCA studies the environmental aspects and potential impacts throughout a product's life cycle (i.e., cradle-to-grave) from raw materials acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences.

- ISO 14001: Environmental management system
- ISO 14010: Environmental Audits
- ISO 14020: Environmental labelling
- ISO 14031: Environmental Performance Assessment
- ISO 14040: Life cycle assessment
- ISO 14050: Terms and definitions

How did the LCA begin...?

>1969Year

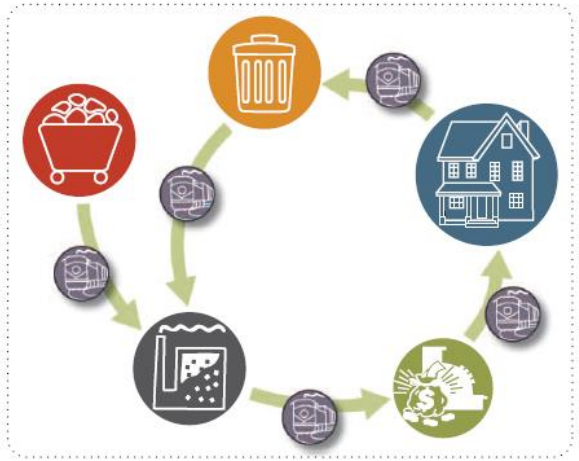
The Coca-Cola Company quantifies and compare different types of bottles

From fragile and heavy glass bottles to plastic bottles made from oil. Is it good or not?

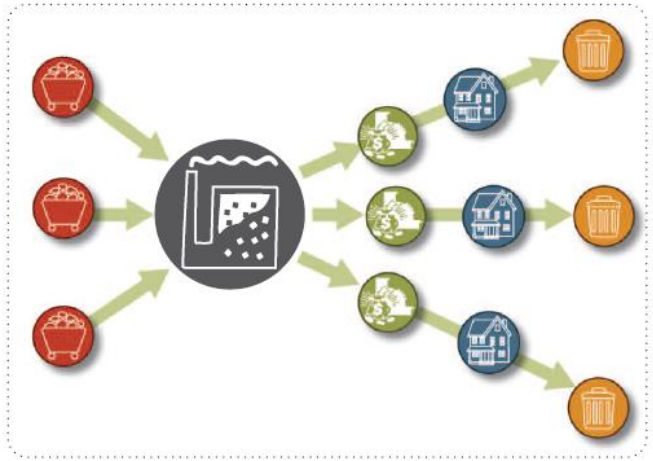
ISO: International Organization for Standardization

Types of LCA

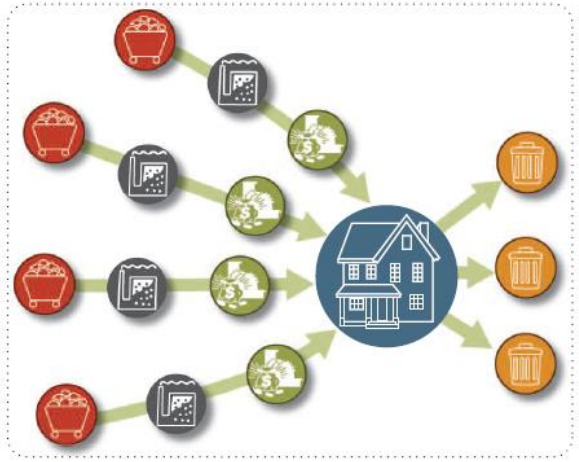
A. Product level LCA



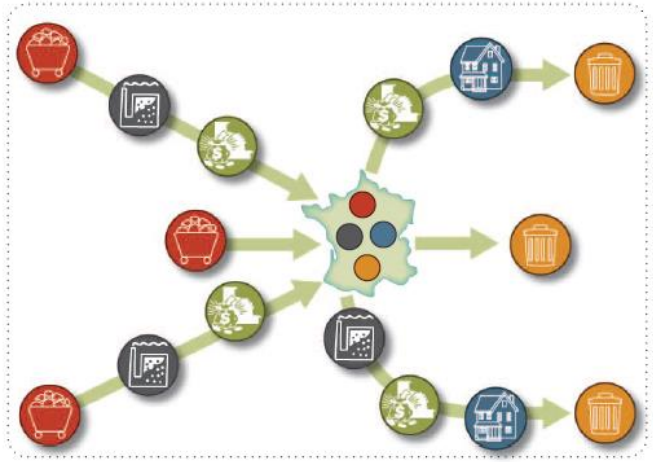
B. Organizational LCA



C. Consumer/lifestyle LCA

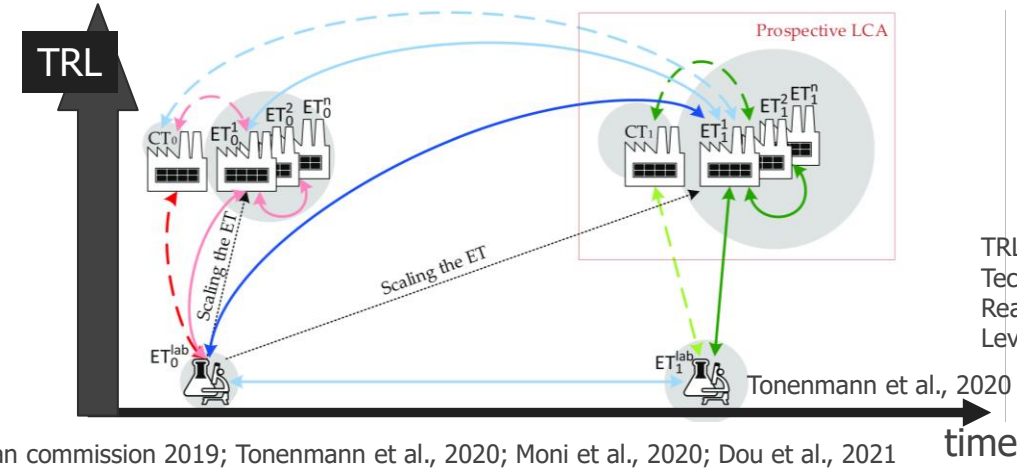


D. Country LCA



Stefanie Hellweg and Llorenç Milà i Canals
Science **344**, 1109 (2014);
DOI: 10.1126/science.1248361

Prospective LCA / Ex-ante LCA / Consequential LCA



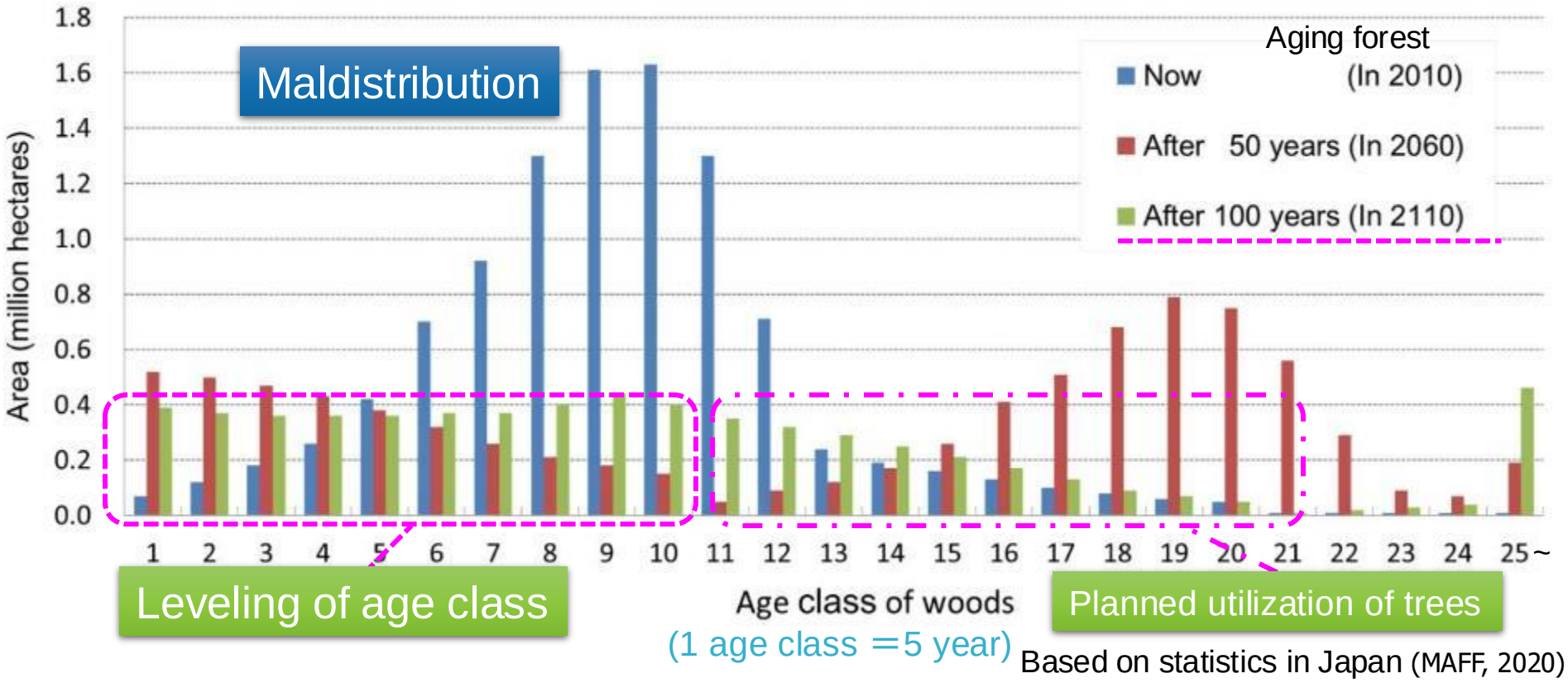
TRL: Technology Readiness Level

Tonenmann et al., 2020

European commission 2019; Tonenmann et al., 2020; Moni et al., 2020; Dou et al., 2021

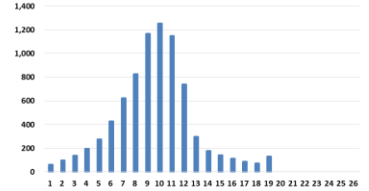
- Increase in publications on "carbon sources"
  - For scientifically-verifiable visualization of environmental performance
  - To facilitate technology development and implementation
- Common conclusions
  - Hotspots in primary industries
  - Differences in recycling systems
  - Necessity of analyzing hydrocarbons considering carbon chains

Reforestation of aging forest in Japan

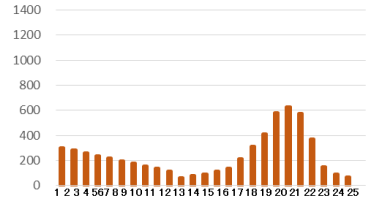


Based on statistics in Japan (MAFF, 2020)

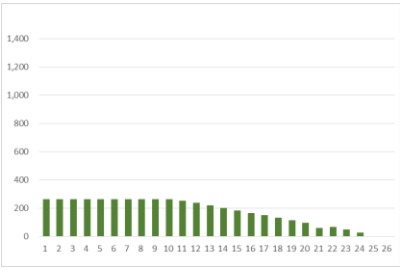
Current



- Aging forest
- Low metabolization



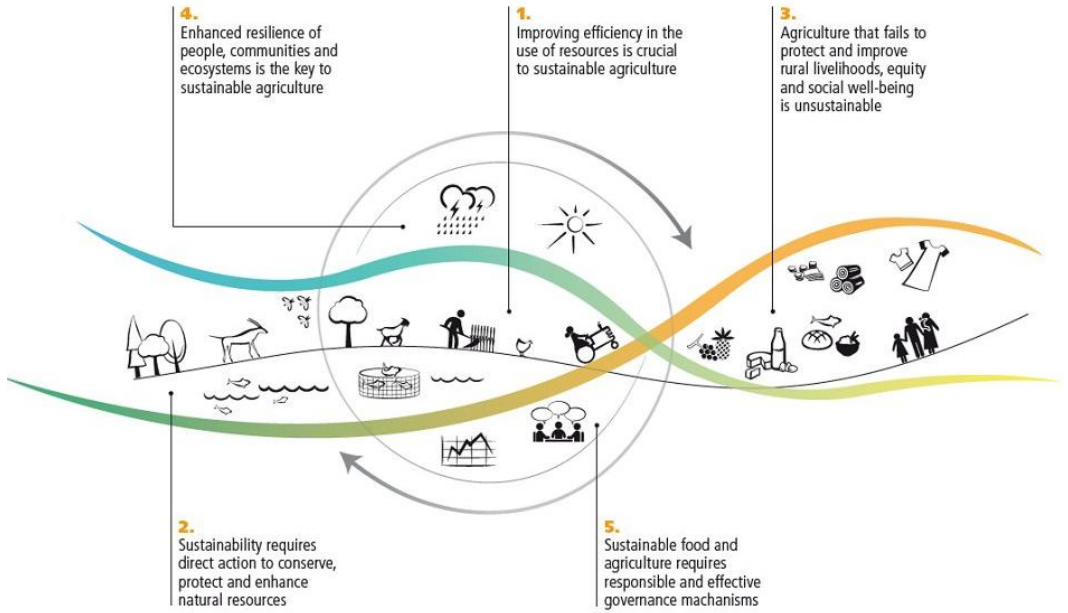
Preferable



- ✓ Sustainable
- ✓ Adequate carbon absorption

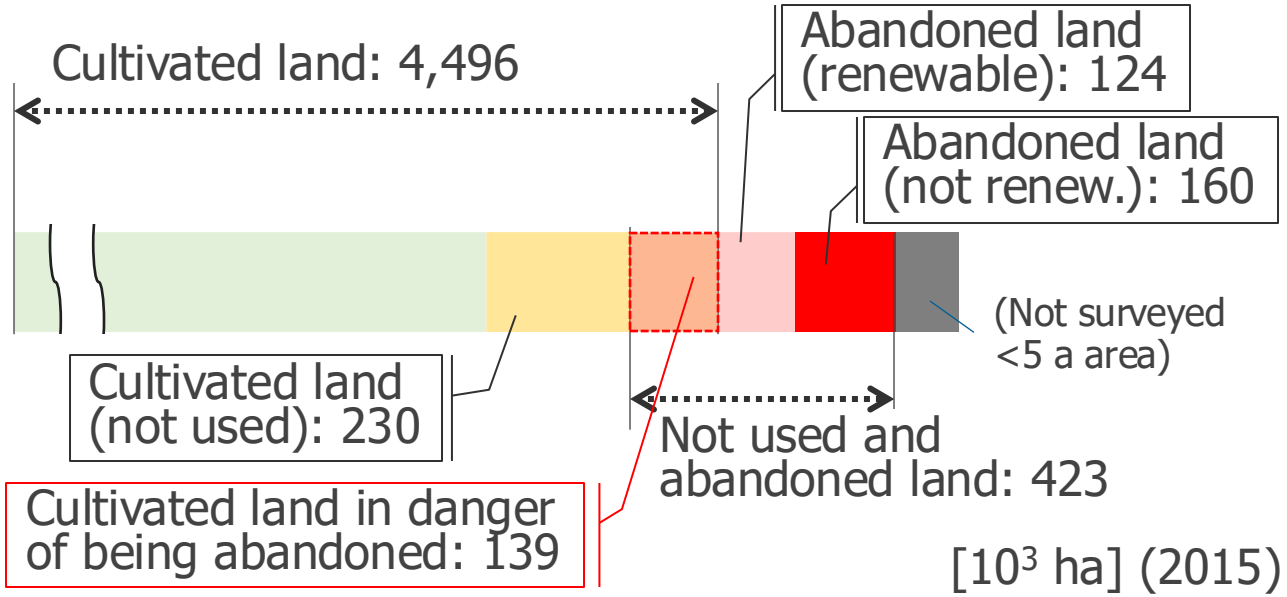
- Forest management for sustainable forest and forest resources
  - The current aging forest should be changed into a preferable distribution
  - Ultra-long-term planning for forest metabolization is inevitable for reforestation, e.g., more than 200 years
- Dynamic management in the face of increasing natural disasters

Revitalization of agricultural industries



- Japan's situation: Abandonment has occurred by depopulation
  - Good land status for cultivation, but no farmers around the land
- Difficult to convert to raw material use when food is arable
  - Lost opportunity to resume cultivation

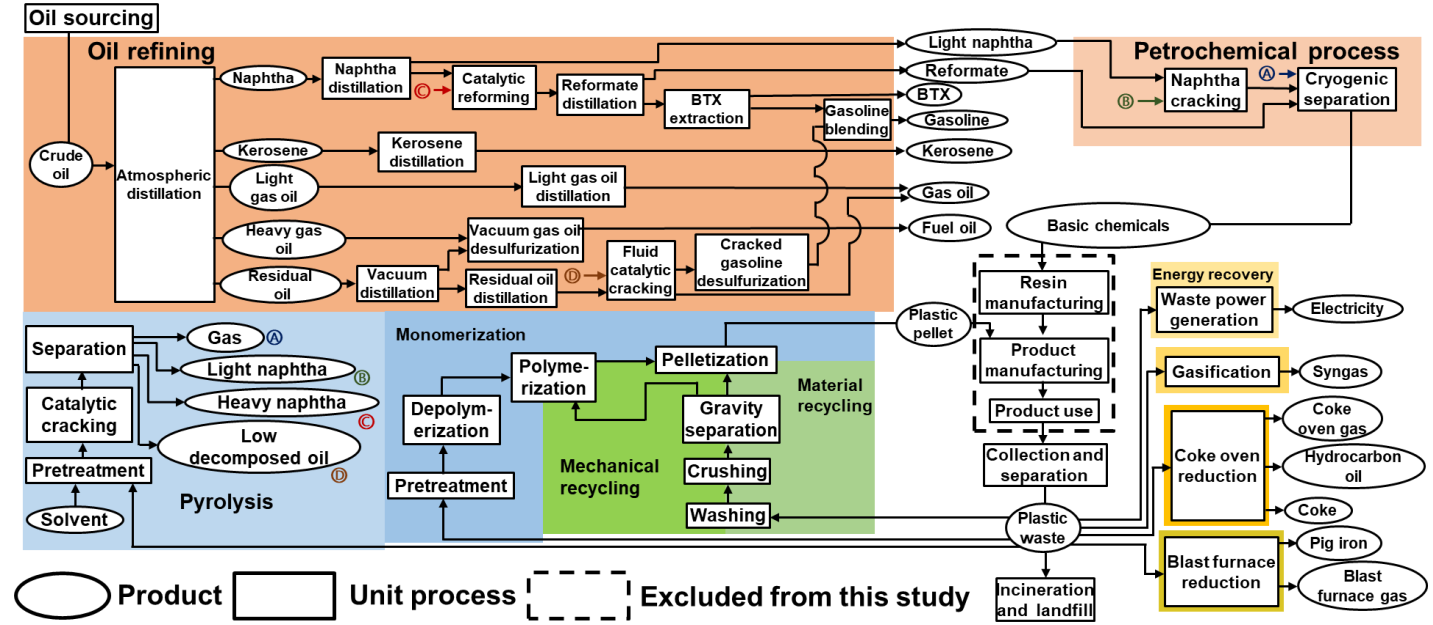
- Sustainable food production and agriculture (http://www.fao.org/sustainability/en/)
  - Community creation, resource management, ecosystem development
- Concerns about diverse environmental impacts
  - Nutrients, water, land use change
- Adaptation to climate change

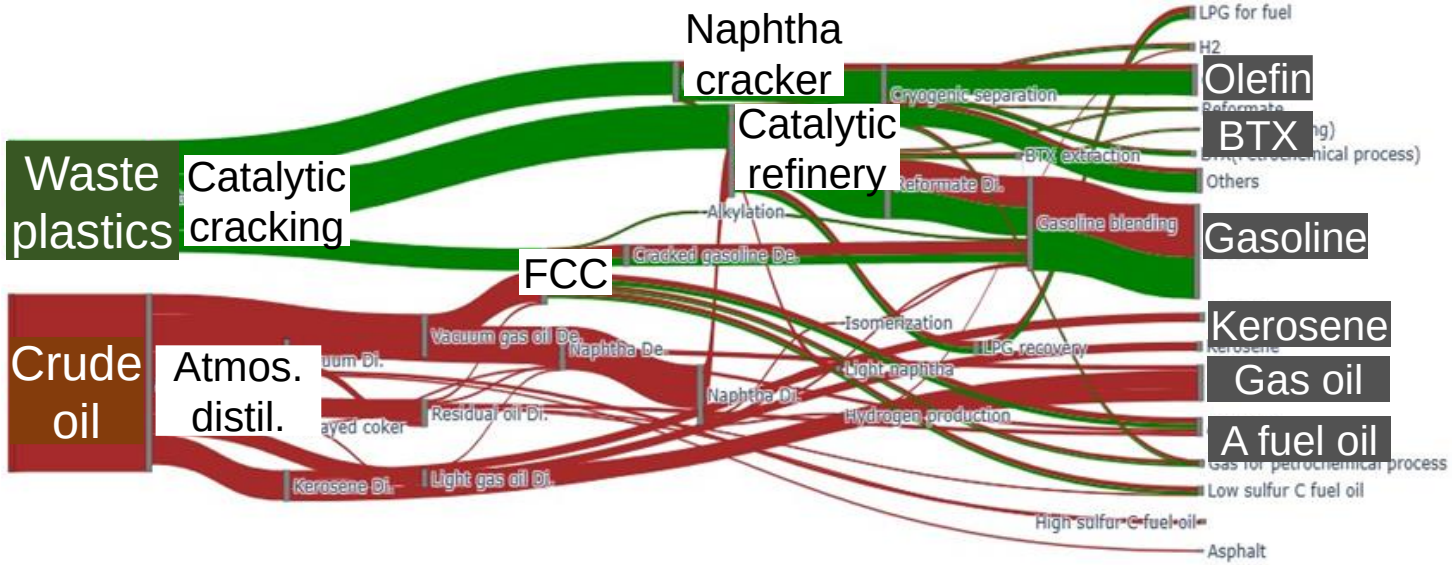


Strategic circulation of carbon resources: Case on feedstock recycling of plastics

Nakamura, et al., 2024

- Simulation of carbon flows in oil refinery and chemical industries clarifies the material flows of carbons derived from multiple products
  - Carbons obtained from catalytic cracking of plastics have specific flow characteristics in oil refineries based on their chain length.
  - Specification of plastics-cracked oil is necessary for understanding what is produceable from waste plastics.
- Biomass- and recycling-derived unconventional raw materials for oil refinery should be multiplied for eliminating crude oil from refinery





Summary

- Renewability of carbon sources is dependent on the local conditions
  - Vegetation varies with agricultural and forestry conditions, climate, ecosystems, topography, industrial infrastructure, and changes in the results of practices

- The application of renewable carbon sources instead of fossil should link to the revitalization and intensification of related industries in Japan
  - Reforestation of aging forests
  - Revitalization of agriculture
  - Strategic circulation of carbon resources

- "Rules", or regulations, standards, guidelines, schemes, and others, could become the lubricant to shift from the current "fossil economy" to a "circular-bio economy"
  - Rules related to local commons should be made regionally
  - Transition phases require various mechanisms
    - e.g., mass-balance model, and feed-in-tariff

- Scientifically informed discussion and communication is inevitable

Acknowledgement

CO-JUNKAN

COI-NEXT

NEDO New Energy and Industrial Technology Development Organization

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科研費 KAKENHI

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