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Roadmaps towards a climate neutral petrochemical production system

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Background and purpose

Important sector

- (Petro) chemical industry is one of the largest energy consuming sector in both countries.
  - Chemical / petrochemical industry shares 24% of industrial energy consumption in both countries.

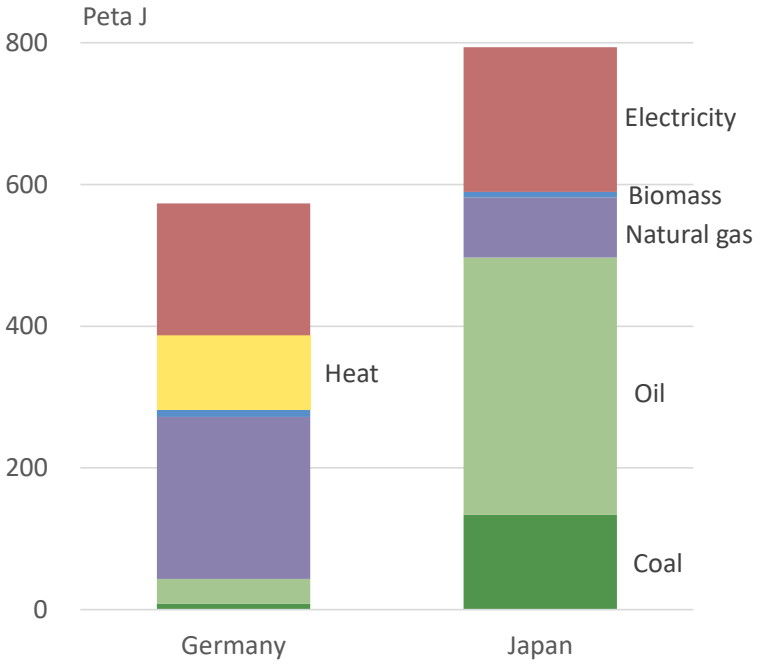
Difficult sector

- Since carbon is used as a material to manufacture products, carbon neutralization also requires a change in the supply of feedstocks.

Learning opportunity

- There may be opportunities for mutual learning in the strategies of both countries.

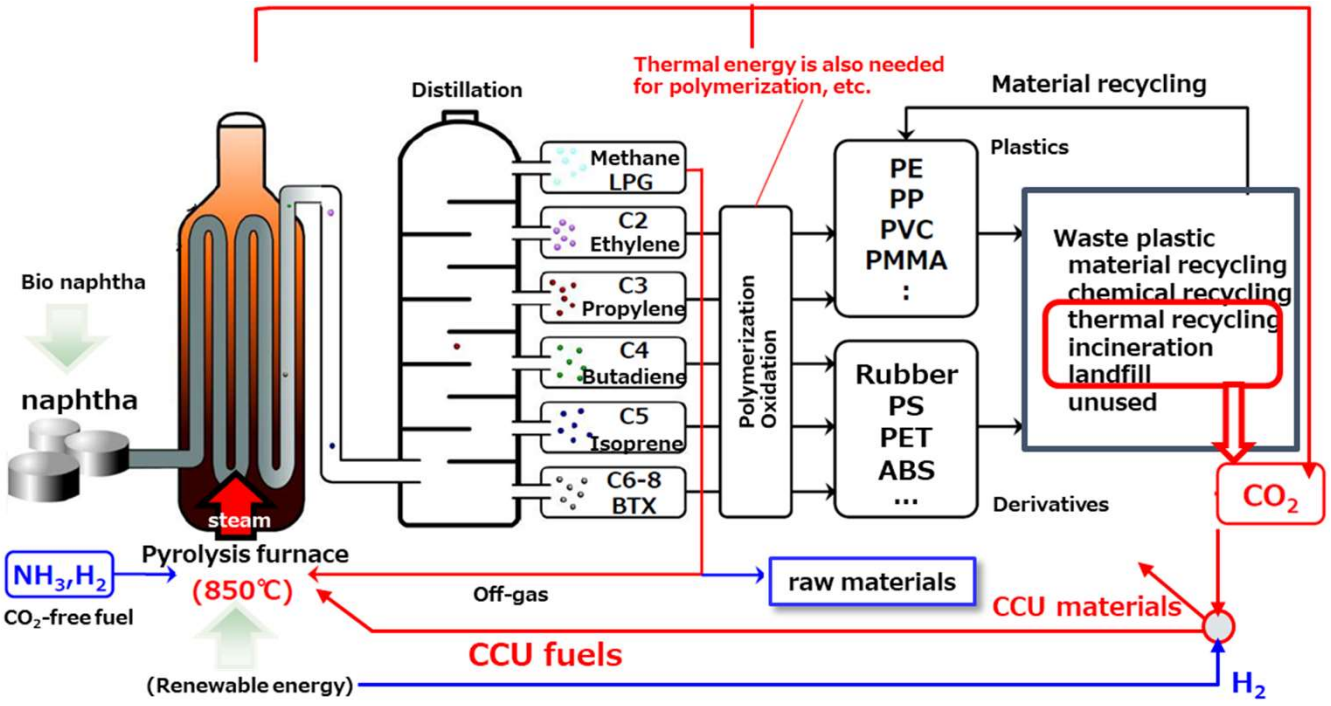
Energy consumption in Chemical / petrochemical industry (2021)



Source: IEA 2023

Japan: Key strategies

e.g. Naphtha cracking furnace



Strategy for feedstock

- Biomass-derived feedstocks (e.g. bio-naphtha) or CO_2-derived alternative feedstocks to petroleum products should use.

Strategy for electricity

- Renewable energy, nuclear power, biomass are desirable, but there are limitation in available amount.

Strategy for heat and steam

(1) Effective utilization of waste heat
(2) CO_2-free heat sources (H_2, NH_3, CCU fuel to produce heat)
(3) Use of electrothermal conversion

- In case of CCU fuel, the CO_2 should be recovered and circulated again (Carbon recycling)

Japan: Key findings

- Weak in tangible action plan for 2030 and beyond.
  It need to be materialized in line with future technological progress.

- Existing strategy rely on un-commercialized technologies such as hydrogen, ammonia, and CCU.
  Advancement of the technologies (cost reduction) is essential, thus should promote its RD&D.

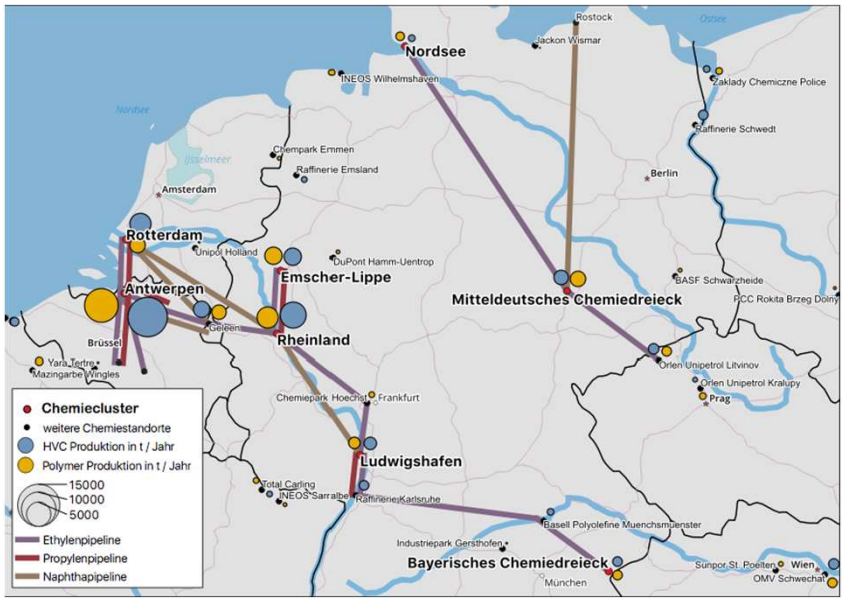
- In recent years in Japan, surplus petroleum and petrochemical capacity has been increasing as the domestic market shrinks.
  Therefore, there is a growing need to consolidate production facilities before investing in decarbonization.
  - Some strategies seek to increase international competitiveness by getting ahead of the decarbonization.

Germany: Industrial context and available roadmaps

German chemical industry

- The direct emissions: 5.3% of Germany‘s emissions
- Organized in integrated clusters

Title	Made by	Commissioner
Roadmap Chemie 2050 Auf dem Weg zu einer treibhausgasneutralen chemischen Industrie in Deutschland	Dechema and FutureCamp	VCI
Wege in eine ressourcenschonende Treibhausgasneutralität	UBA	-
dena-Leitstudie – Aufbruch Klimaneutralität	EWI	dena
KLIMAPFADE 2.0 Ein Wirtschaftsprogramm für Klima und Zukunft	BCG	BDI
Langfristszenarien für die Transformation des Energiesystems in Deutschland 3	Consentec, Fraunhofer ISI, ifeu, TU Berlin	BMWi
Deutschland auf dem Weg zur Klimaneutralität 2045 Szenarien und Pfade im Modellvergleich	Kopernikus-Projekt Ariadne and Potsdam-Institut für Klimafolgenforschung (PIK)	BMBF



Roadmaps:

- Scenario analyses for net-zero energy systems until 2045 or 2050
- By governmental institutions and industry associations

Germany: Chemical industry roadmaps

Strategies, energy and carbon sources

Main strategies for defossilisation:

- CO_2+hydrogen-based feedstock (can be imported)
- Biomass feedstock (controversial)
- Chemical (and mechanical) recycling

- Methanol-based production
- Electrified steam crackers

Carbon/feedstock sources:

Roadmap	Scenario	Fossil	Recycling	Biomass	CO2 and H2
Wege	(All scenarios)	0%	nq	22%	78%
RoadChem	Technology pathway	46%	12%	29%	14%
	GHG neutrality pathway	6%	11%	28%	55%
KlimaPfade	Proposed path	0%	30%*	0%?	70%
Langfrist	TN-Strom	0%	nq	0%	100%
	TN-H2	0%	nq	0%	100%
	TN-PtG/PtL	0%	nq	0%	100%
DenaLeit	KN100	19%	nq	9%	72%

Most energy is electrified

- PV and wind power from national grid
- Complemented with other renewable sources

Germany: Challenges and recommendations in roadmaps

Central challenges

- Lacking business case and large uncertainties
- Speed

Policy recommendations

- Setting direction, coordination, planning, and long-term comittment
- Global level playing field, or compensation

Conclusions from study of German roadmaps:

- Limited domestic resources
  → global markets for certain renewable resources
- The path forward is far from clear
- Conditions for the industries and decarbonization options are developing rapidly

Conclusions: Similarities and differences

Similarities	Differences
Context: • Size, import dependence, high energy prices	**Context:** • Geographical connections to other countries, current energy mix to chemical industry
Roadmaps: • Mid-century net-zero targets • Limited domestic renewable resources • Importing synthetic fuels and feedstocks	**Roadmaps:** • Future physical connections: ship transport ←→ grid and pipelines • Non-feedstock energy use: range of imported fuels ←→ green electricity • Framing: energy security and efficiency ←→renewable, sustainable, supply security

Conclusions: Recommendations

Opportunities for collaboration

- Learning together and from each other:
  - Green chemical energy carriers and feedstocks
  - Biopolymers, CO2-based technologies, chemical recycling
  - Efficient and flexible energy supply systems
  - Policy incentives
- Developments of global markets and supply chains for renewable chemicals

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Thank you for your attention!