9th November 2022

Thomas Adisorn
Wuppertal Institute (WI)

Yoshikazu Kobayashi
Institute of Energy Economics Japan (IEEJ)

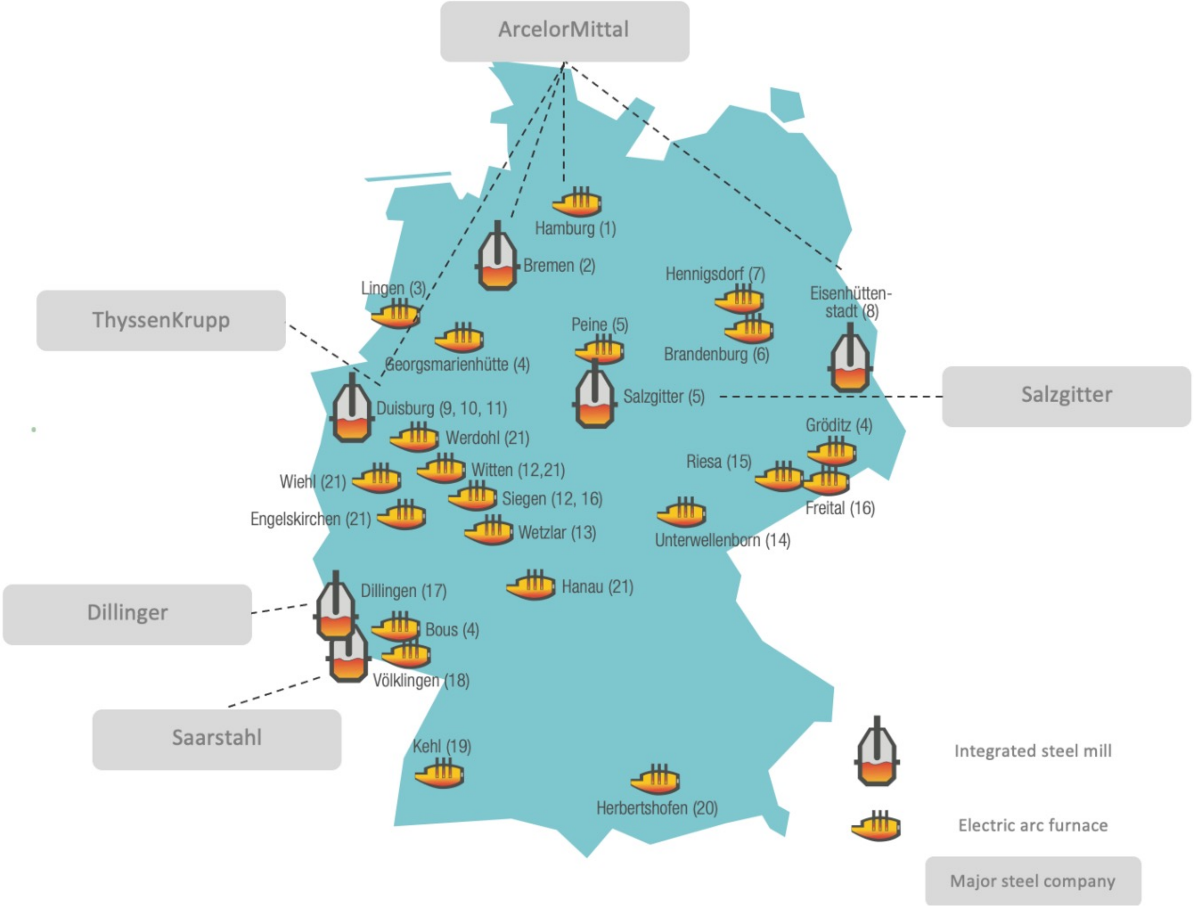
Decarbonization of the Steel Industry

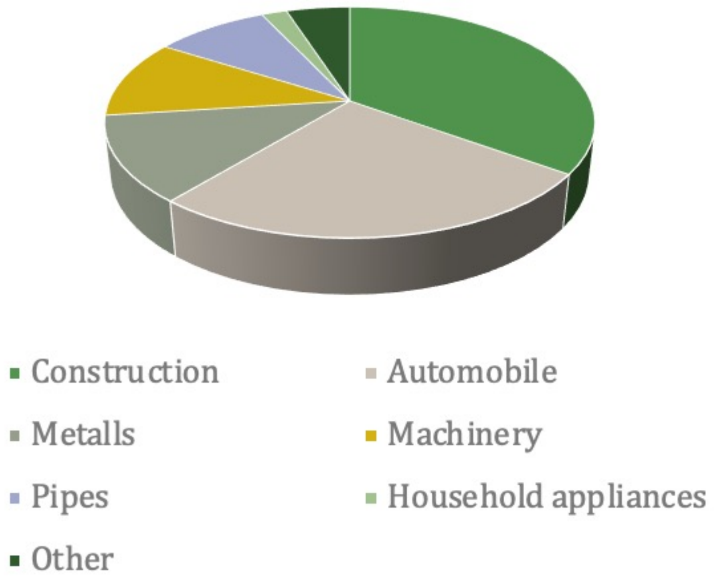
Structure

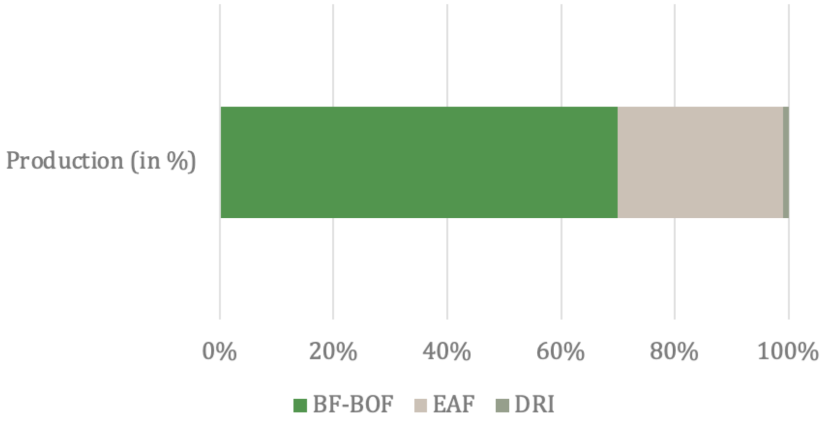
GJETC

- Industry Overview Germany
- Decarbonization Roadmap Germany
- Industry Overview Japan
- Decarbonization Roadmap Japan
- Comparison
- Policy Recommendations

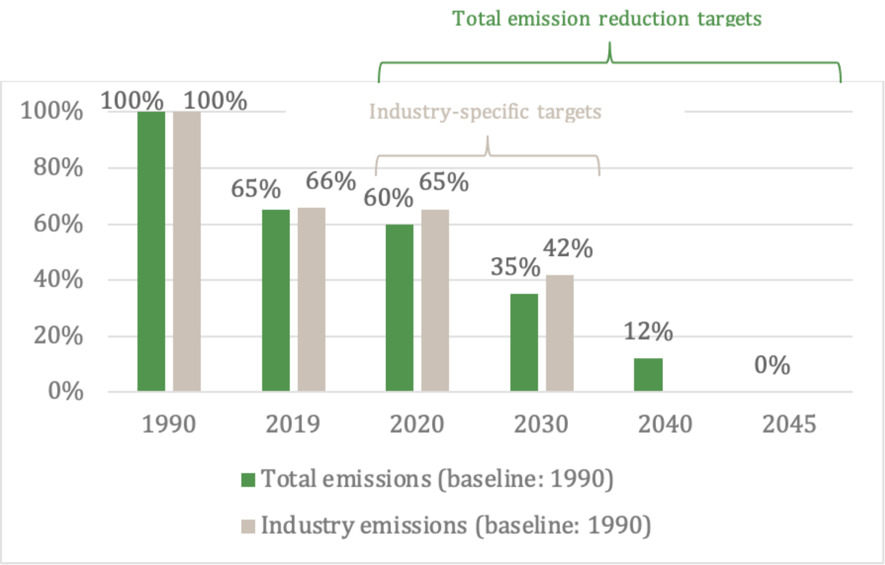
Industry Overview: Germany

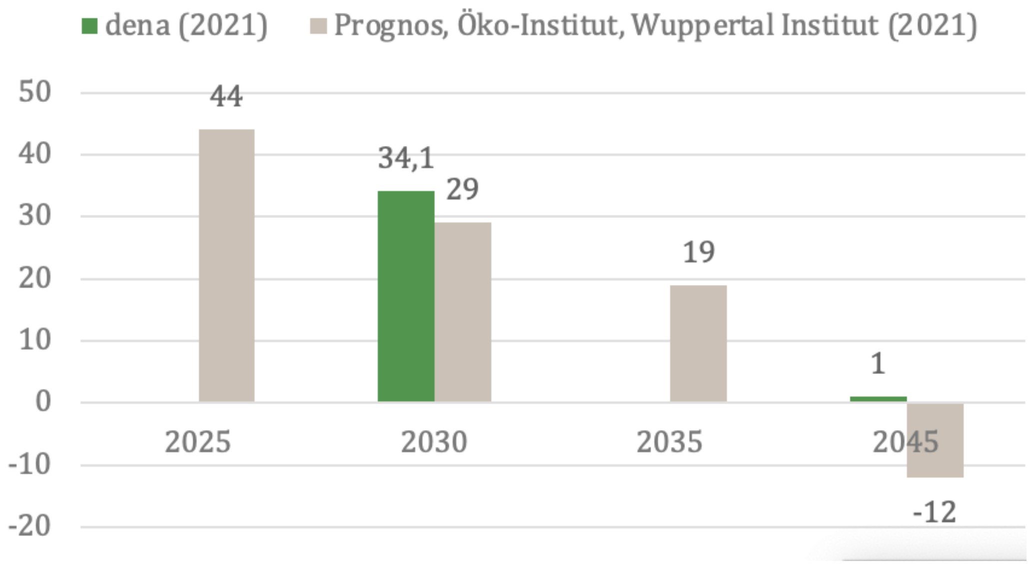






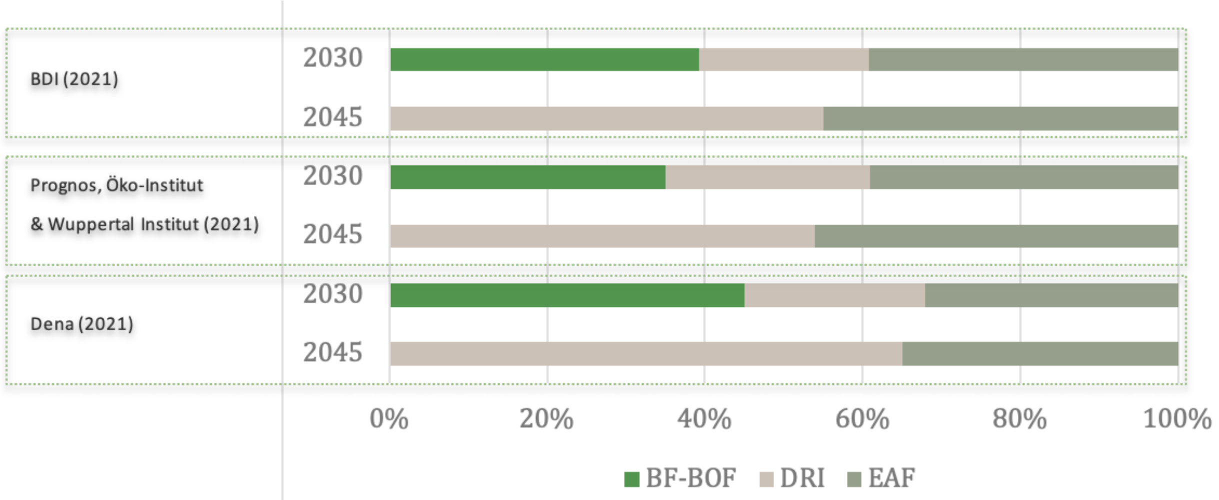
Decarbonization Roadmap: Germany





Key Technology Pathways

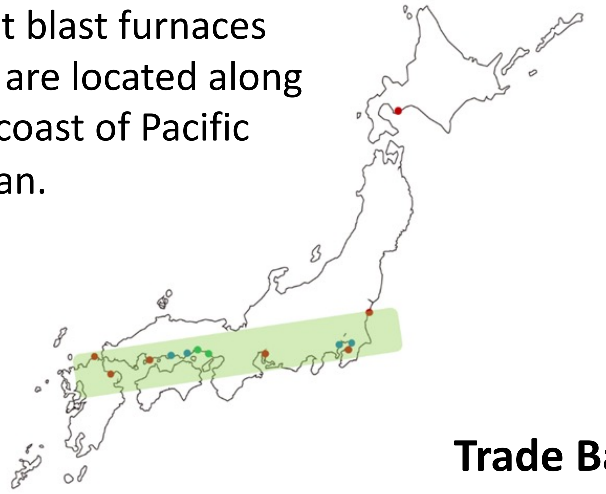
- Increase of EAF route
- DRI with NG used in the transition phase before turning to 100% hydrogen
- CCU(S) with bioenergy



Industry Overview: Japan

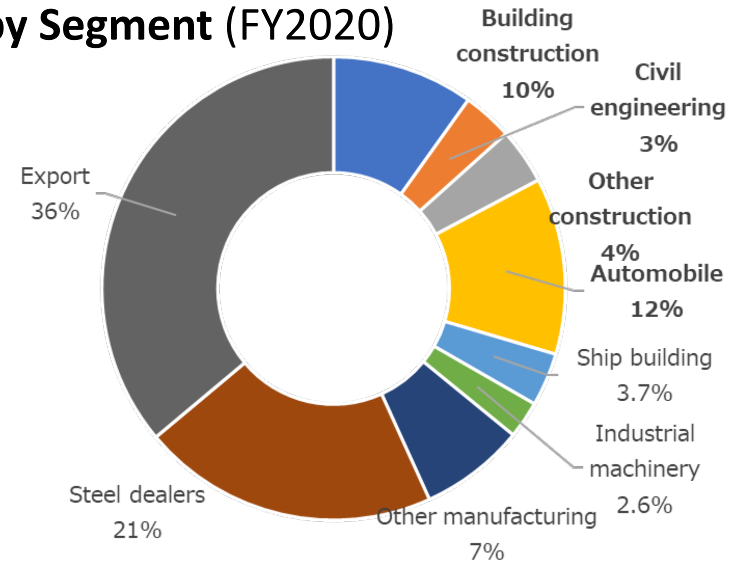
Locations of Blast Furnaces in Japan

Most blast furnaces (BF) are located along the coast of Pacific Ocean.



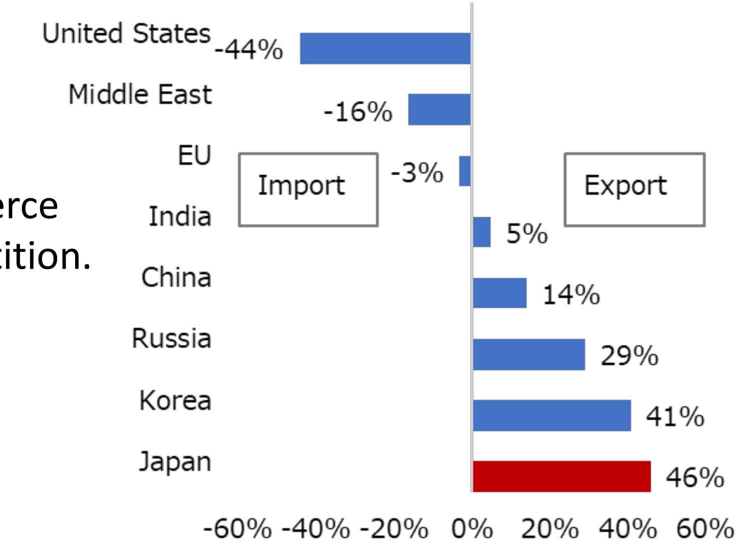
Steel Demand by Segment (FY2020)

Automobile and building construction are major demand segment.

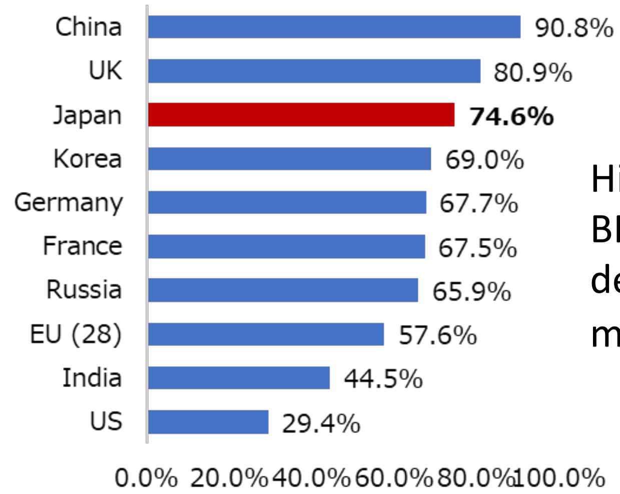


Trade Balance of Steel (2018)

The industry faces fierce international competition.



Crude Steel Production by Process (2020)

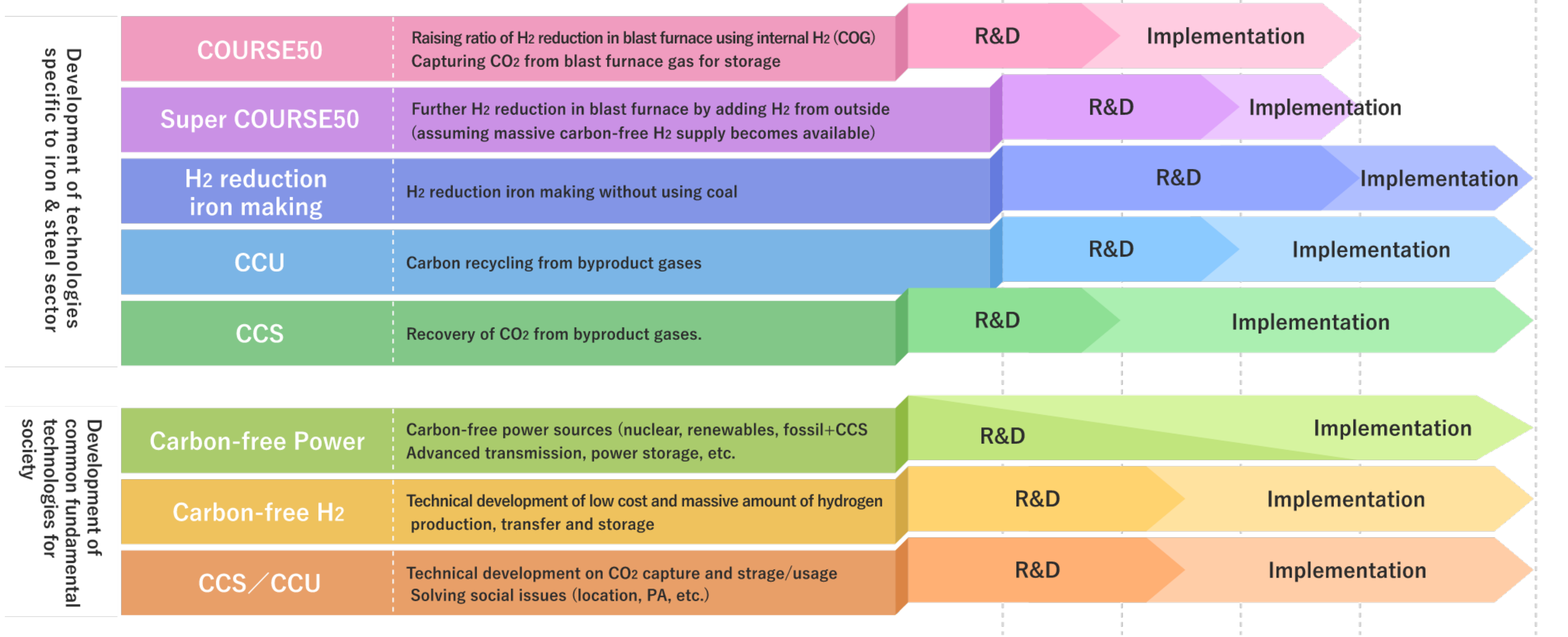


High dependence on BF, which makes decarbonization more challenging.

Decarbonization Roadmap: Japan

- Utilization of hydrogen and CCUS are the two major means to decarbonize blast furnace. Electrification based on zero-emissions power is also pursued.
- While public-private partnership (COURSE50) plays a pivotal role, each steel maker sets its own mid-year targets with specific reduction technology developments.

Roadmap Toward Carbon Neutrality



Comparison

Decarbonization actions of both countries' steel industry have a lot in common; but there are also nuanced differences:

Commonalities	Differences
• **All major companies have mid-term (2030) targets and aim for long-term full decarbonization.** • **Utilization of hydrogen as fuel** • **Direct reduction by hydrogen** • **Carbon, capture, utilization, and storage (CCUS)** • **Biomass as fuel** • **Electrification (raising the share of electric arc furnace)**	• **Public-Private Partnership program (J)** • **Assumed products by CCU application** - Chemical products (G) vs Methane (J) • **Direct reduction by natural gas (G)** • **Bio energy carbon capture and storage with oxyfuel (G)** • **Utilization of ferro coke (J)** • **Major sources of hydrogen** - More weight on the domestic green H2 (G) vs both green and blue H2 (J) • **Major sources of zero emissions electricity** - Renewable (G) vs various zero-emission generation sources incl. renewable, nuclear, and hydrogen/ammonia (J)

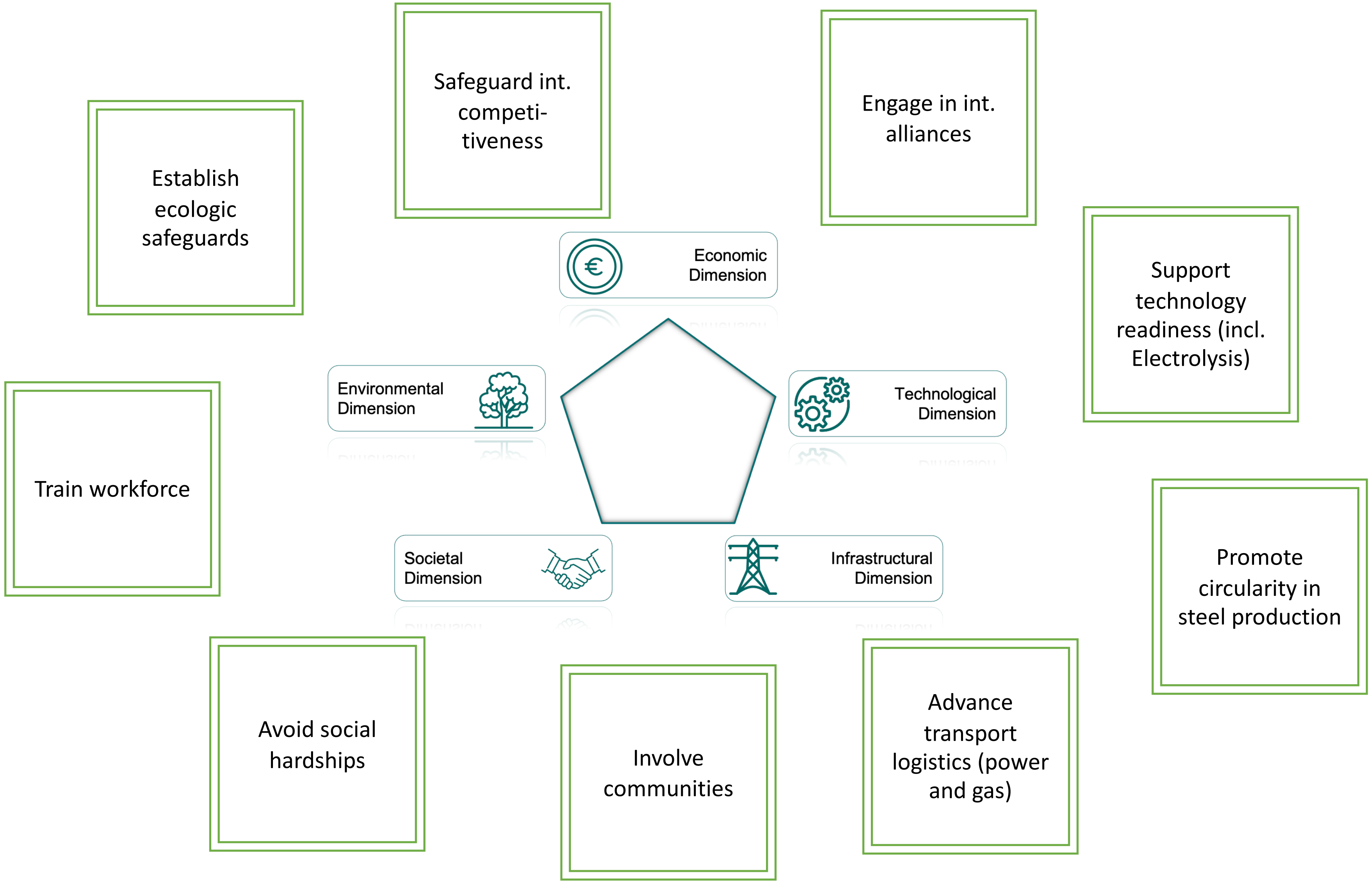
Economics

GJETC

DRI-technology offers a good compromise due to its potential to reduce emissions almost completely.

Technology	Abatement costs (2030)	Abatement costs (2050)	Additional costs (2050)	Expected applicability
Direct reduction	60-99 EUR / t CO_2	85-144 EUR / t CO_2	36-61%	2025-2030
CCU	231-439 EUR / t CO_2	178-379 EUR / t CO_2	63-119%	2025-2030
HIsarna / CCS	n. a.	25-45 EUR / t CO_2	9-16%	2035-2040
Iron electrolysis	n. a.	170-292 EUR / t CO_2	65-112%	2050

Policy recommendations: Germany



Policy Recommendations: Japan

Item	Policy
Cost-competitive clean hydrogen	• R&D supports for more competitive electrolysis process • Development of import clean hydrogen/ammonia hub • Infrastructure development of the domestic hydrogen supply network
Innovative steel-making technology	• Intensive R&D support at an earlier stage • More weight on the pilot testing and commercialization at a later stage
CCUS application	• Legal and regulatory development to operationalize CCS • Diplomacy to secure overseas storage location
Zero emissions electricity	• Realization of power generation mix as of 2030 and expected reference figures as of 2050
Financing	• Completion and refinement of the industrial decarbonization roadmap for transition finance
Market acceptability of zero-carbon steel	• Burden sharing mechanism of incremental cost across the entire supply chain