Potentials for overseas DRI/HBI production
Initial findings and conclusions of 1st internal assessment

Short summary for policymakers

31 March 2023
thyssenkrupp Steel Europe AG

Context

- Steel is the base for many **integrated value chains** and key for Europe's strategic autonomy.
- Today, the steel industry emits about **10% of global CO_2 emissions**, 80% of which are generated in the initial step of primary steel production – the reduction of iron ore.
- **Solutions exist.** Traditional blast furnaces using coal as reduction agent must be substituted by **hydrogen-based direct reduction plants in combination with melting units** (Direct Reduced Iron – DRI – needs to be melted before it can be further processed into steel).
- **Multi-billion euro investments in this change of technology are underway** across Europe, supported by government funding.
- With DRI as feedstock, **steel will become a major off-taker of renewable energy and green hydrogen.**
- Cost of renewable energy sources (RES) and hydrogen will largely determine **competitiveness** of green steel production in Europe.
- **Currently, energy prices in Germany are significantly higher compared to other countries and regions**. Thus, **questions arise** as to what extent DRI production should rather be established in regions with abundant RES and thus lower DRI production cost.
- To this end, thyssenkrupp steel carried out an **initial cost comparison between local production in Germany versus potential DRI/HBI production abroad / overseas** in order to understand **longer-term strategic options**.

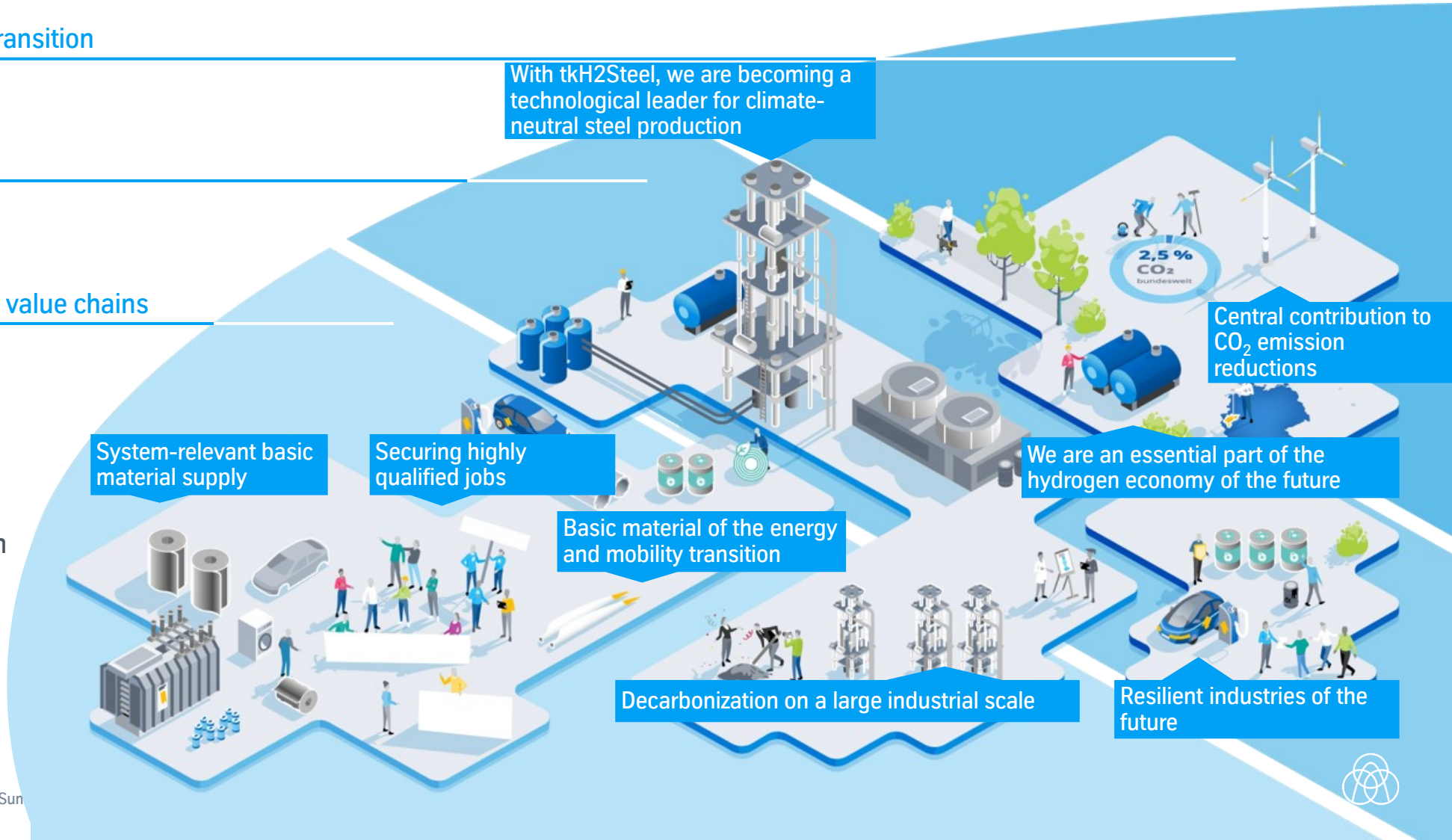
thyssenkrupp Steel – “green” steel for Europe’s strategic autonomy

Our first hydrogen-ready DR-plant is underway

3 Our steel: pioneer in green transition

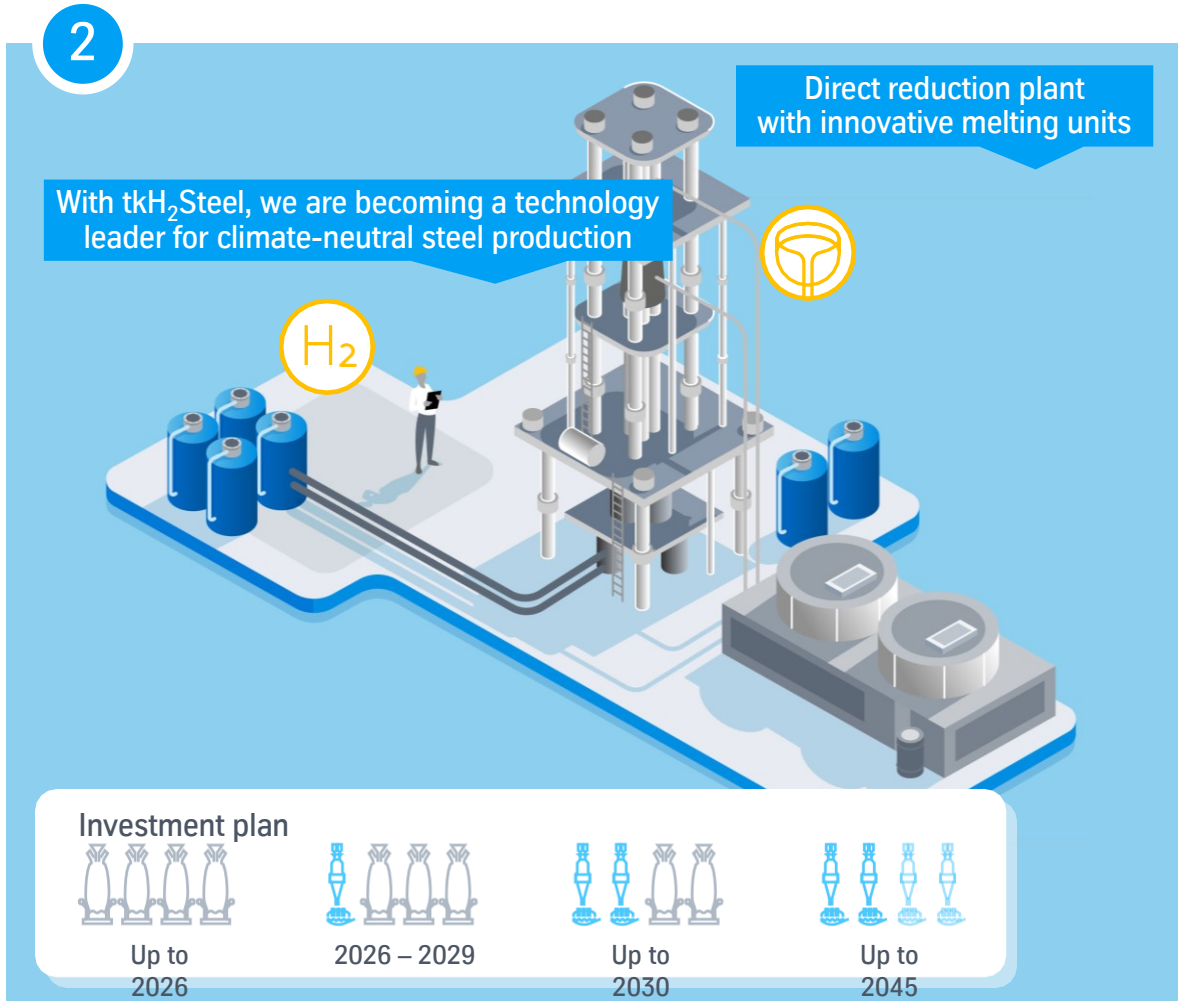
2 Our steel: is going green!

1 Our steel: basis for strategic value chains



A climate-neutral, resilient European economy needs green steel.
We are pushing ahead with our green transition and an investment in breakthrough technology and securing jobs in future oriented industries.

Our steel is going green – we plan to decarbonize already half of our production by 2030



Sustainable investments in the future

We are replacing blast furnaces with direct reduction (DR) plants and melting units – while maintaining the range of grades and full quality

H_2 We will replace coking coal with green hydrogen in the medium term and will be connected to the European hydrogen network from 2027 onwards

Our timetable

2022 Investment approval for first direct reduction plant – total volume two billion euros

2026 Startup of the first DR plant

2030 Commissioning of second DR plant and production of 5 million metric tons of low-CO_2 steel

2045 Climate-neutral production and replacement of all coal-based blast furnaces with alternative solutions.

In the future all steelmakers will face the question whether to make DRI locally or to buy/import HBI

Options	Build own DR plant on site	Buy/import DRI/HBI
Description	• Continue to build DR plants together with melting units locally (i.e. in Duisburg in case of tk Steel) • Fully benefit from integrated supply chain and especially „hot link“[1]	• Build only melting units on site • Source HBI either with partner or via off-take agreements
Key rationale	• Long-term competitive energy costs in Europe • Positive environment for investments in large scale CAPEX projects in Europe (e.g. funding, financing aid,…)	• Long term non-competitive energy cost in Europe (for DRI/HBI production) • Local incentives to build energy/HBI hubs outside Europe (e.g. subsidies, tax credits, etc.)

Key principle

- **All production steps from smelting to steelworks and downstream processes remain in Germany/Europe**
- **No liquid/merchant green HBI market expected in the short to mid-term future**

1 Charging of the hot DRI directly from the DR unit into the smelter; compared to sourcing of HBI with the need for re-heating

Different archetypes for external DRI/HBI sourcing have been subject to a first assessment

Key success criteria

- **Access to sufficient and cheap green electricity** for H2 production
- **Access to DRI grade iron ore** supply and pelletizing capacity
- **Access to required infrastructure**, e.g., deep seaport and bulk logistics
- **Offtake agreement with key customers**
- **Resilience** to absorb uncertainties, e.g., technology, regulatory

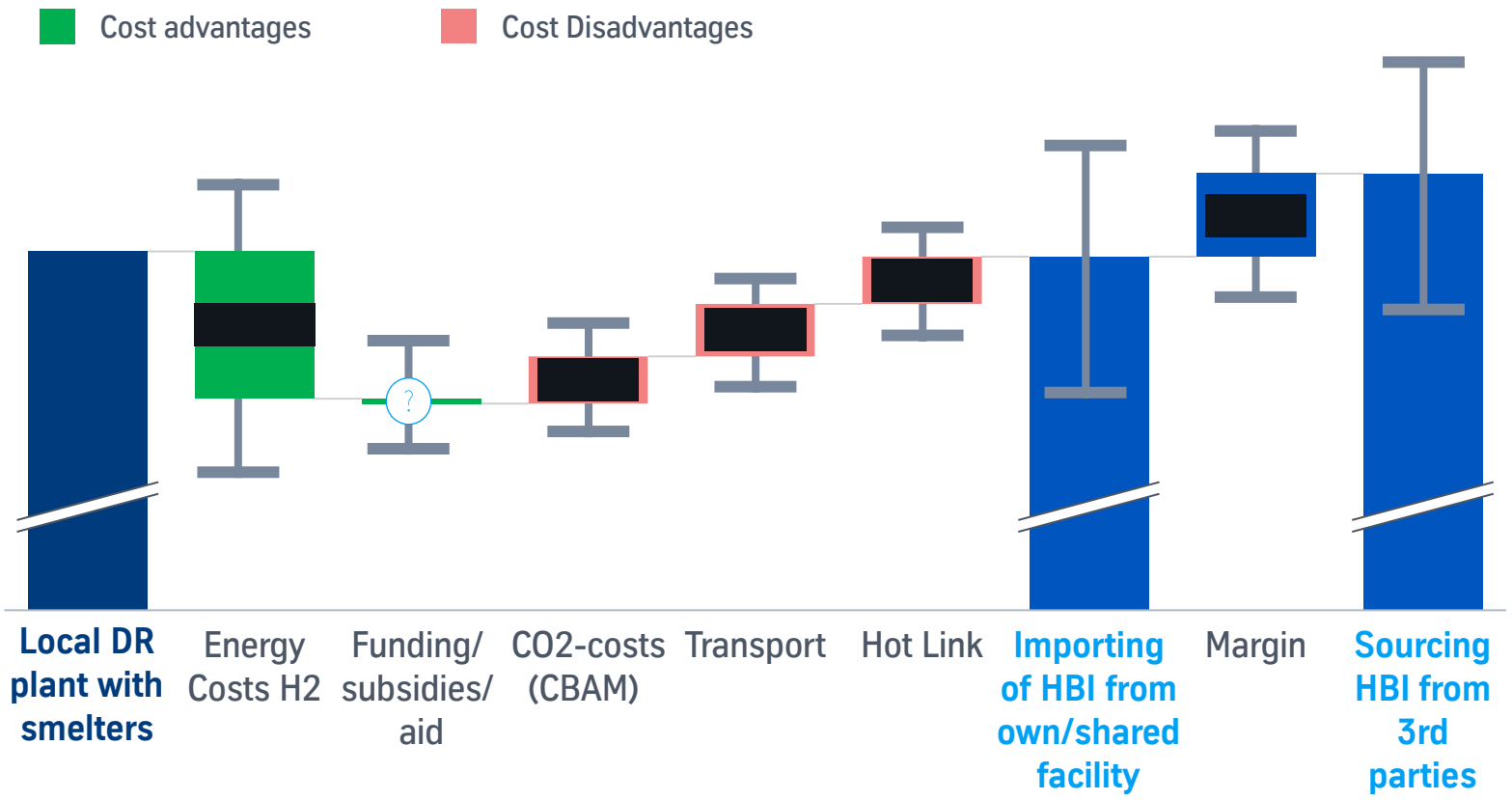
Archetype	Location (example)	Rationale
Energy hub with upside from subsidies	 [redacted]	Favorable RES, access to blue H2, favorable infrastructure, possible IRA subsidy access
Proximity to iron ore and grid-based green H2	 [redacted]	Green H2 from low-cost grid electricity, proximity to DR pellets
Advantageous RES[1] and proximity to iron ore	 [redacted]	Proximity to DR pellets from Canada, favorable RES (onshore wind)
Middle east location with high share of solar power	 [redacted]	Favorable RES due to location; high local political interest to further drive industrialization
EU location with advantageous RES	 [redacted]	Favorable RES (in EU), EU jurisdiction risk mitigation, possible EU subsidy access

Initial focus on green H2, widened to blue H2 and alternative options such as natural gas + CCS

1 Renewable energy supply

Initial findings suggest that there is no clear business case for importing HBI

Initial cost comparison



Key drivers

Advantages:

- Delta in H2 costs key driver for attractiveness of HBI import (1€/kg H2 cost delta results in ~[redacted]€/t cost delta for HBI); access to cost competitive hydrogen import (e.g. via pipeline from ESP/PRT) may narrow gap
- Funding/state aid schemes for local H2/energy production (e.g. IRA, industry energy price) may widen or narrow the gap

Disadvantages:

- Details on CBAM regulation and impact on cost structure to be determined
- Transport: DRI is a very porous and reactive and must be compacted at a temperature greater than 650° C to so-called Hot Briquetted Iron (HBI) in order to prevent corrosion and self-heating (inflammation) during transport and handling. Compaction of DRI increases energy demand and adds cost.
- Hot-link: Energy demad in SAF process increases by up to 40%. While HBI can be charged hot (>500°) in an integrated plant, it needs to be re-heatet in case of shipping

"Make vs. Buy" ist currently not a straightforward decision and vastly dependent on highly uncertain parameters

Main conclusions

- We continue our transition roadmap as planned with a first H2-ready, integrated DR/SAF combination on site in Duisburg and will continue replacing all our current blast furnaces.
- We currently plan to have a second DR/SAF up and running before 2030 and will need to make our next investment decision latest in 2024. This requires us to closely monitor and analyse the key parameters, especially the development of energy prices and the regulatory environment both in Europe as well as in third countries.
- Establishing an industry energy price (e.g. 7 cts/kWh) will be a precondition to unlock investments in equipment for renewable energy and hydrogen production and thus for providing infrastructure for a competitive DRI-based steel production in Europe.
- As appropriate, we proactively share facts and figures with the EU and national governments to inform policy developments and contribute to the further development of the EU Net Zero Industry Act.