ESTEP SPRING DISSEMINATION EVENT

5-6 JUNE 2025 KRAKOW (POLAND)

Safe H-DRI

Safe handling and transport of hydrogen-based direct reduced iron for a decarbonisation of the steel industry

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ESTEP

K1 MET metallurgical competence center

Safe H-DRI

HOTEL ★★★★ GALAXY JORDAN GROUP

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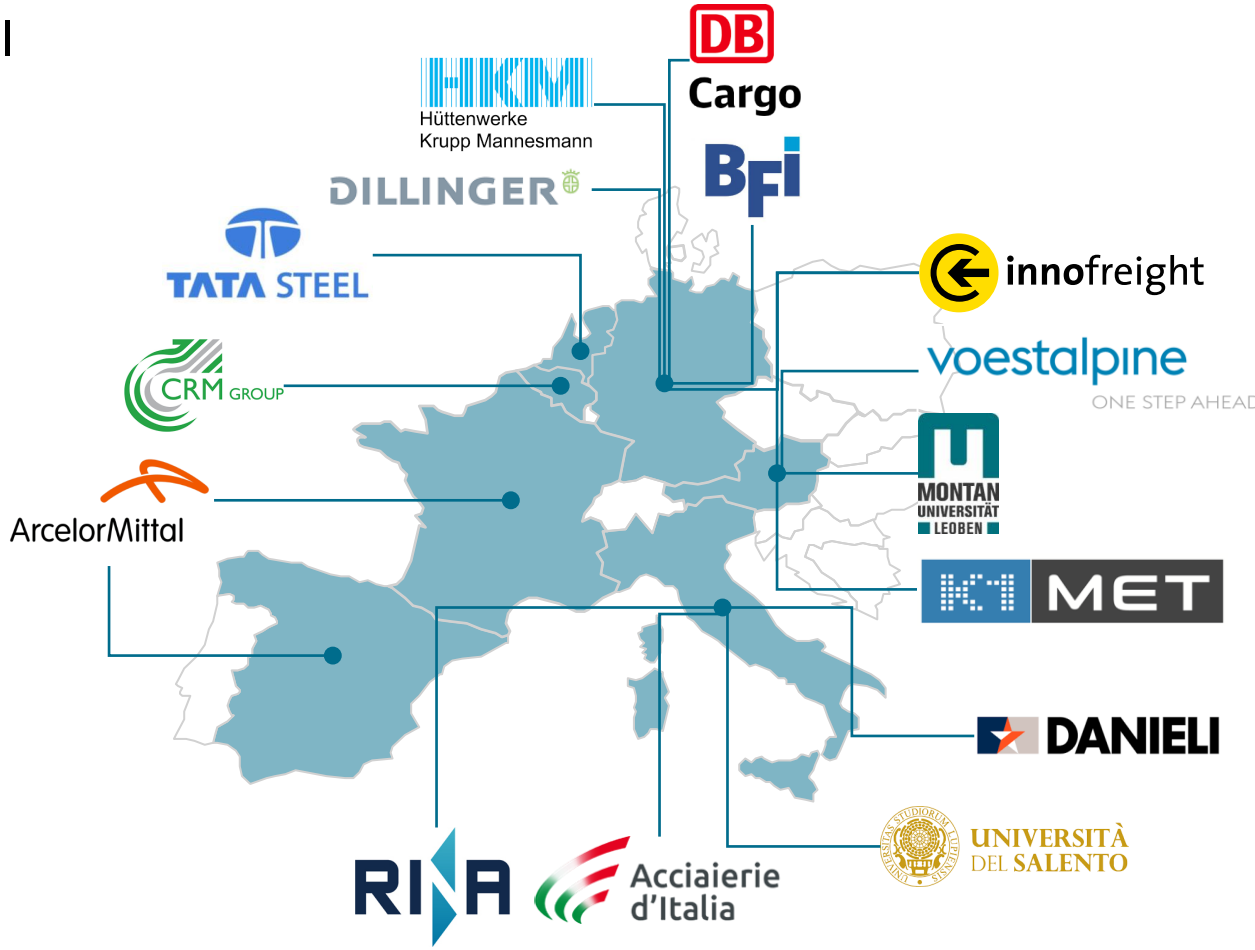
Project overview
Key facts

- Goal (= project long title): Safe transport of DRI from H_2-based direct reduction considering quality-related H-DRI reactivity, stability, the efficiency of passivation methods and health and recycling aspects



Start date
1.10.2024

Duration
42 months

Coordinator
K1-MET (Austria)

Consortium
18 partners

Programme
RFCS, GA n. 1011150482

This project has received funding from the Research Fund for Coal and Steel under grant agreement No 101150482.

Decarbonising primary steel production

The role of H-DRI

- Scrap alone cannot meet global steel demand
  - High-tech steel grades require purer inputs than scrap can in some cases offer
  - DRI dilutes impurities present in lower grades of scrap
- Most available iron ores not of sufficient quality for use in DR-based EAF steelmaking
- To decarbonise the steel industry: production of DRI with hydrogen (H_2)
- H_2 use reduces CO_2 emissions, but impacts:
  - Product properties
  - Resulting performance in downstream processes
  - Final steel quality

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Decarbonising primary steel production
The role of H-DRI

- Rising demand for H_2-based DRI (H-DRI) will increase transport by rail and sea
  - Not all DRI will be produced within the EU or directly at steel production sites

- DRI with high metallisation degree (e.g., from NG/H_2-based DR processes) is reactive, posing safety risks during transport and storage
  - Exothermic reactions (e.g., self-heating in humid conditions)
  - Reactions with moisture produce hydrogen and oxygen, increase explosion risk

- Knowledge gaps remain regarding:
  - H-DRI stability regarding cracks and fines formation
  - Reoxidation behaviour during H-DRI transport with related handling
  - Recycling of fines formed during transport

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Project objectives
Key goals

Develop a sustainable and efficient logistic chain for H-DRI

Adapt **container design** and tailor for **loading, transport and storage processes** to specific requirements of H-DRI

Enhance the **use of low-grade iron ores** and **resulting fines** to produce H-DRI with 100% H_2 or mixtures of H_2 and NH_3

Examine **reoxidation behaviour** under **transport/storage conditions** like humid air, saltwater, temperature variations

Quantify **crack and fines formation** during handling to assess **reuse potential** and mitigation strategies

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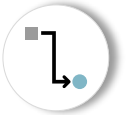
Project objectives
Key goals

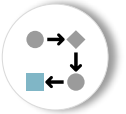
Ensuring safety and support standardisation

Identify critical safety parameters by linking variations in H-DRI quality (metallisation, gangue content, particle size) to potential hazards and risks

Examine and test **passivation methods to reduce risks** like self-heating, ignition, local explosions during transport and handling



Assess **downstream impact on** loss of metallisation, particle sizes and dust composition



Support transport system **standardisation** and **update exiting transport guidelines** based on new knowledge regarding H-DRI behaviour

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Concept of the project

Highlighting the relevant part of the H-DRI chain

Safe H-DRI

Varying iron ore qualities

Direct reduction

Pellets, lump ore

H_2, NH_3

H_2-based Direct Reduced Iron (H-DRI)

Reoxidation (H-DRI reactivity)

Varying reoxidation conditions

Lab-scale tests

Thermogravimetric analysis (TGA)

Varying H-DRI quality

Varying passivation methods

Crack formation analysis
H-DRI passivation
Transport system design

H_2O, O_2

Fe metallic

Dust & fines

Briquetting

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Key activities
Understanding H-DRI Behaviour

H-DRI production and reoxidation

Using different ore qualities and agglomerated resulting fines
Lab-scale reoxidation trials under defined conditions and in real environment

Examination of H-DRI stability

Correlations between H-DRI quality, dust formation, hazards, and risks
Determination of breaking behaviour and crack formation

Recycling and circular economy

Reusing and reintegrating fines into the production process
Reducing material losses
Supporting zero-waste goals

Process analysis and quality evaluation

Chemical analysis
Determination of metallisation loss
Physical properties
Morphological structure and phase identification

Passivation techniques

Coatings and controlled aging
Minimise H-DRI reactivity
Improve safety

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Current activities
Key activities

Experimental activities:

- Selection of pellet grades used for experiments (DR and BF grade)
- Round robin test for quality assurance, started with agreed methodologies (ICP, XRF, TGA,…)
- Adaption of H-DRI breakage test facility ongoing
- First practical experience with new designed TGA plant for reduction / passivation
- H-DRI market analysis and stakeholder consultation started

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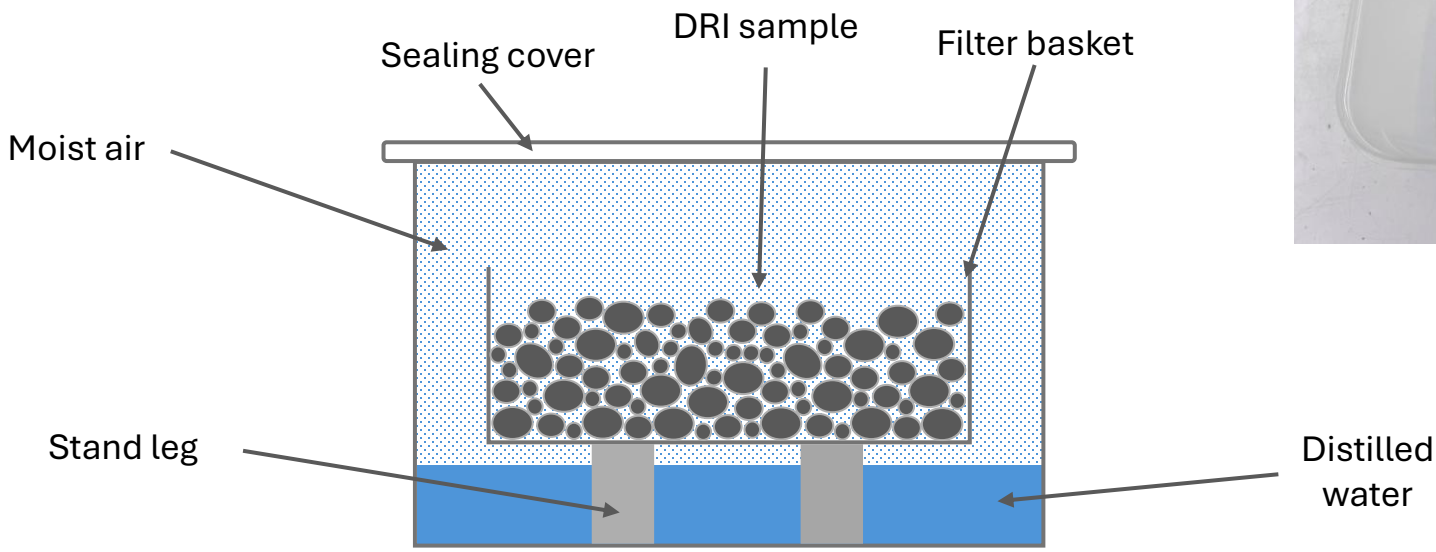
Current activities
Lab-scale reoxidation trails

- Preliminary tests with commercial DRI
- Box 1: dry air at room temperature
  - Reference test
- Box 2: moist air above deionised water at room temperature
- Test duration: 8 weeks



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Current status
Key activities

✓ Establishment of communication platforms:

- Website launched! (*https://safe-h-dri.eu/*)
- LinkedIn page created! (*https://www.linkedin.com/company/safe-h-dri-project/*)

Scan to follow us on LinkedIn

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❑ What's next?

- Finalisation of reduction conditions for H-DRI production
- Definition of reoxidation conditions and experimental set-ups
- Reoxidations tests in lab-scale
- Commissioning of test rig and performing first tests with H-DRI breakage test facility

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Thank you!

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05. June 2025