



**Steel making technology  
using hydrogen: COURSE50  
- A challenge towards Zero-carbon STEEL -**

**February 18<sup>th</sup>, 2021**

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**NIPPON STEEL CORPORATION**

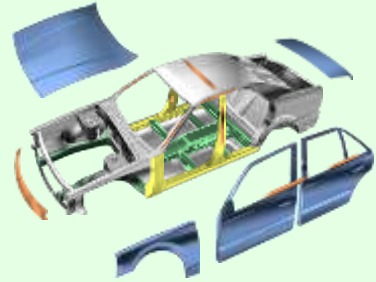
# Steel supports our lives



Cans



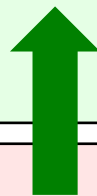
Home appliances



Cars

Railroads  
Ships  
Bridges

Steel products



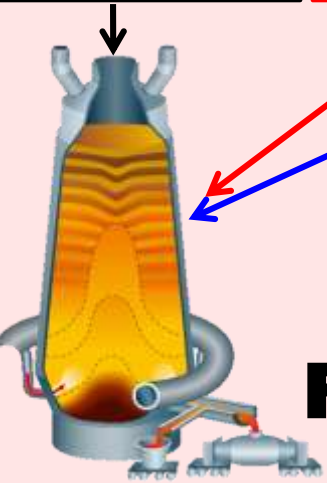
Iron Ore

**Fe<sub>2</sub>O<sub>3</sub>**

Coal

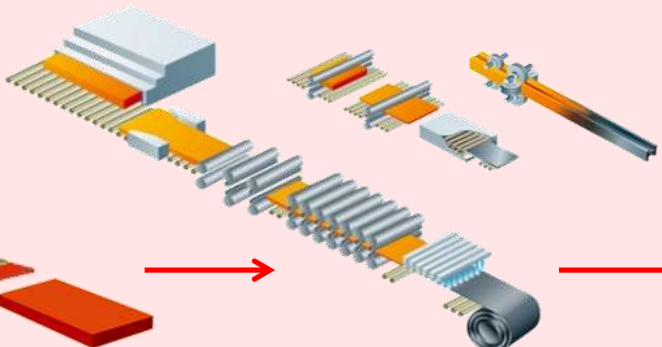
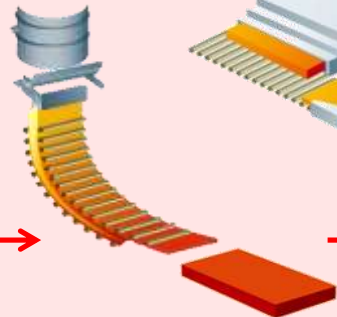
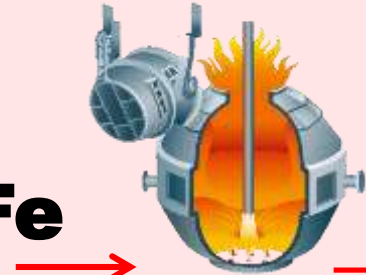
**C**

**H<sub>2</sub>**



**Fe**

Blast furnace



Steel making process

# Pathways towards Zero-carbon STEEL

## 1. Carbon capture, sequestration and utilization



CCS (Carbon Capture and Sequestration)

CCU (Carbon Capture and Utilization)

## 2. Using hydrogen as a reductant



A huge amount of carbon-free H<sub>2</sub> supply with rational cost

An innovative technology for heat compensation

# COURSE50: The First Step to the Future

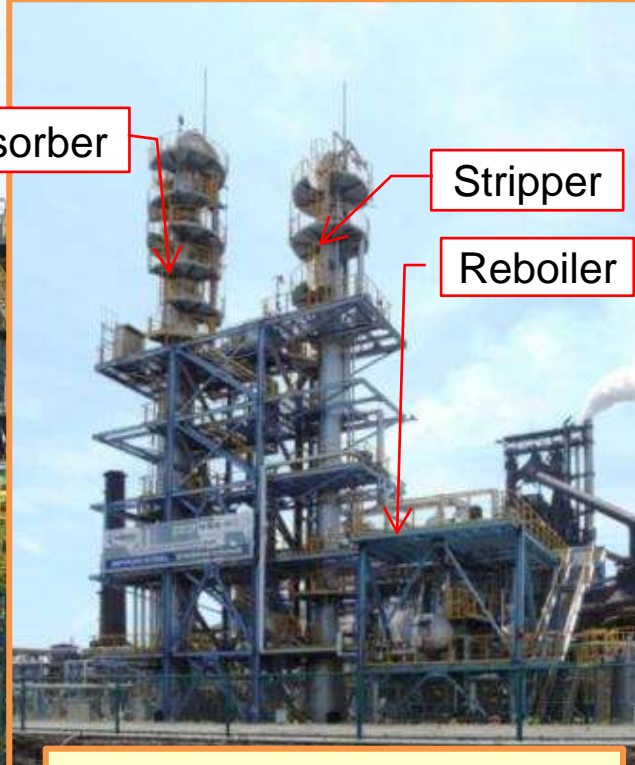
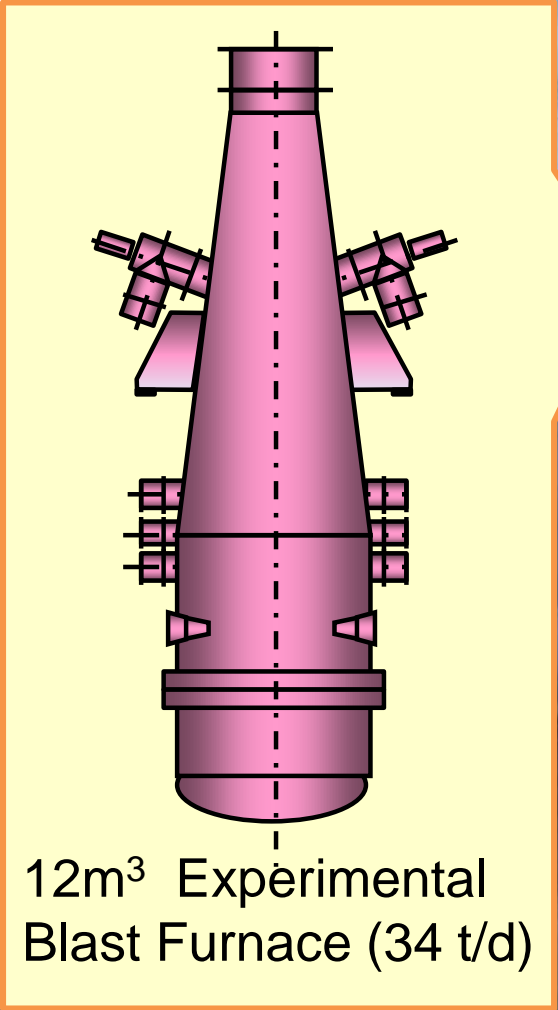
COURSE50: CO<sub>2</sub> Ultimate Reduction System for Cool Earth 50

100%-sponsored research project by NEDO (New Energy and Industrial Technology Development Organization)



Using H<sub>2</sub> as a reductant

CO<sub>2</sub> capture



CO<sub>2</sub> separation plant (30 t-CO<sub>2</sub>/d)

# COURSE50: CO<sub>2</sub> reduction by H<sub>2</sub>

COURSE50: CO<sub>2</sub> Ultimate Reduction System for Cool Earth 50

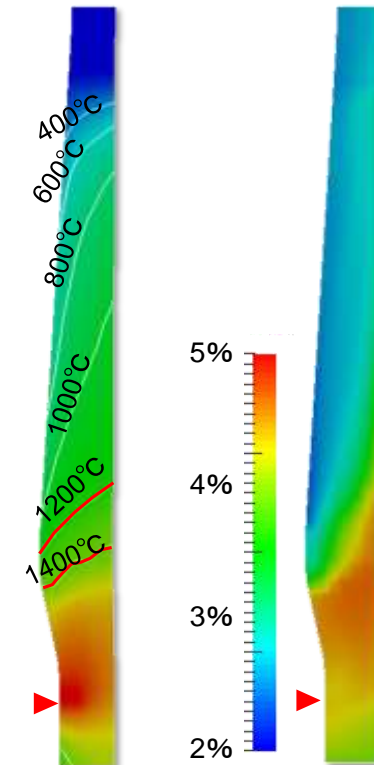
100%-sponsored research project by NEDO (New Energy and Industrial Technology Development Organization)

## Experimental blast furnace



## Calculation by mathematical model

Solid temp. H<sub>2</sub> concentration



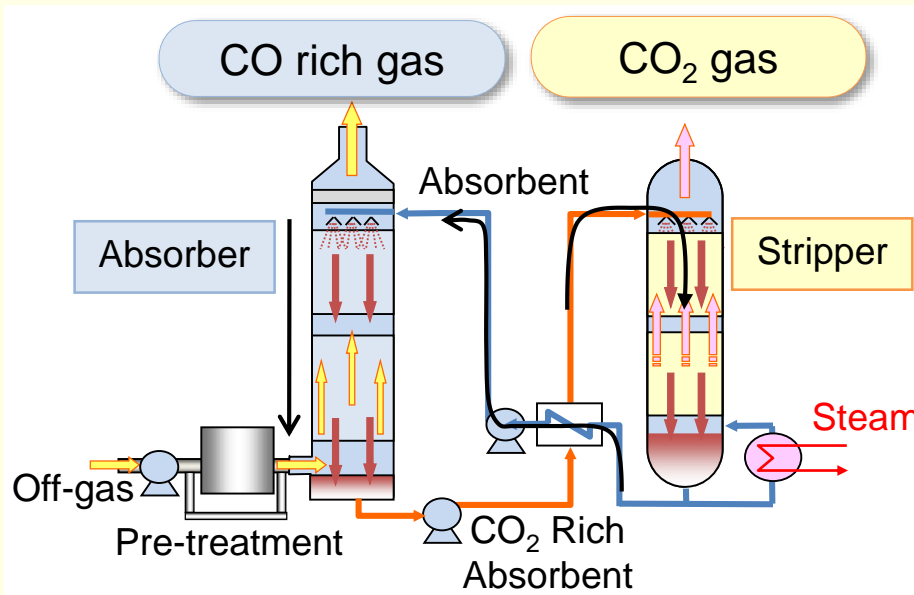
Combination of experiment and calculation helped to achieve  
**10% reduction in CO<sub>2</sub> by H<sub>2</sub>-rich gas in the experimental blast furnace.**

# COURSE50: CO<sub>2</sub> capture

## COURSE50: CO<sub>2</sub> Ultimate Reduction System for Cool Earth 50

100%-sponsored research project by NEDO (New Energy and Industrial Technology Development Organization)

- Basic technology: COURSE50 project
- Chemical absorbent: Nippon Steel & RITE
- Reaction process: Nippon Steel Engineering



ESCAP Process flow

2 commercial plants in operation  
(120 and 143 t-CO<sub>2</sub>/day)



120 tons of CO<sub>2</sub>/day, CO<sub>2</sub> Purity:>99.9 vol%

ESCAP commercial facility  
(Liquid CO<sub>2</sub> Plant for Air Water Carbonic Inc.)

**ESCAP™** (Energy Saving CO<sub>2</sub> Absorption Process) : A trademark of NIPPON STEEL ENGINEERING CO., LTD.

CO<sub>2</sub> separation from blast furnace gas was confirmed.

# Roadmap for Zero-carbon STEEL

## Roadmap for the development of super innovation technologies

Development of technologies specific to iron & steel sector

		2020	2030	2040	2050	2100
COURSE50	Raising ratio of H2 reduction in blast furnace using internal H2 (COG) Capturing CO2 from blast furnace gas for storage	R&D	Implementation			
Super COURSE50	Further H2 reduction in blast furnace by adding H2 from outside (assuming massive carbon-free H2 supply becomes available)		R&D	Implementation		
H2 reduction iron making	H2 reduction iron making without using coal		R&D	Implementation		
CCU	Carbon recycling from byproduct gases		R&D	Implementation		
CCS	Recovery of CO2 from byproduct gases.	R&D	Implementation			

Development of common fundamental technologies for society

		2020	2030	2040	2050	2100
Carbon-free Power	Carbon-free power sources (nuclear, renewables, fossil+CCS) Advanced transmission, power storage, etc.	R&D	Implementation			
Carbon-free H2	Technical development of low cost and massive amount of hydrogen production, transfer and storage	R&D	Implementation			
CCS/CCU	Technical development on CO2 capture and strage/usage Solving social issues (location, PA, etc.)	R&D	Implementation			

JISF Long-term vision for climate change mitigation, Japan Iron and Steel Federation, 2019

- ✓ Very tough technical issues to overcome in hydrogen-reduction ironmaking.
- ✓ Huge and stable supply of carbon-free hydrogen with rational cost.
- ✓ JISF challenges to develop super innovative technologies to realize Zero-carbon STEEL.