Session 5 : Decarbonation of Bulk Materials

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WORLD MATERIALS FORUM

1. Current Situation in the Decarbonization of Materials Production

- Currently available process technologies need further elaboration: efficiency and capacity.
- Associated capital expenditures and operational costs need to be lowered.
- For hydrogen usage, CO2 utilization, etc., further progress and innovation are needed not only in the underlying scientific aspects of technologies but also in their industrialization.

- Common challenges/barriers

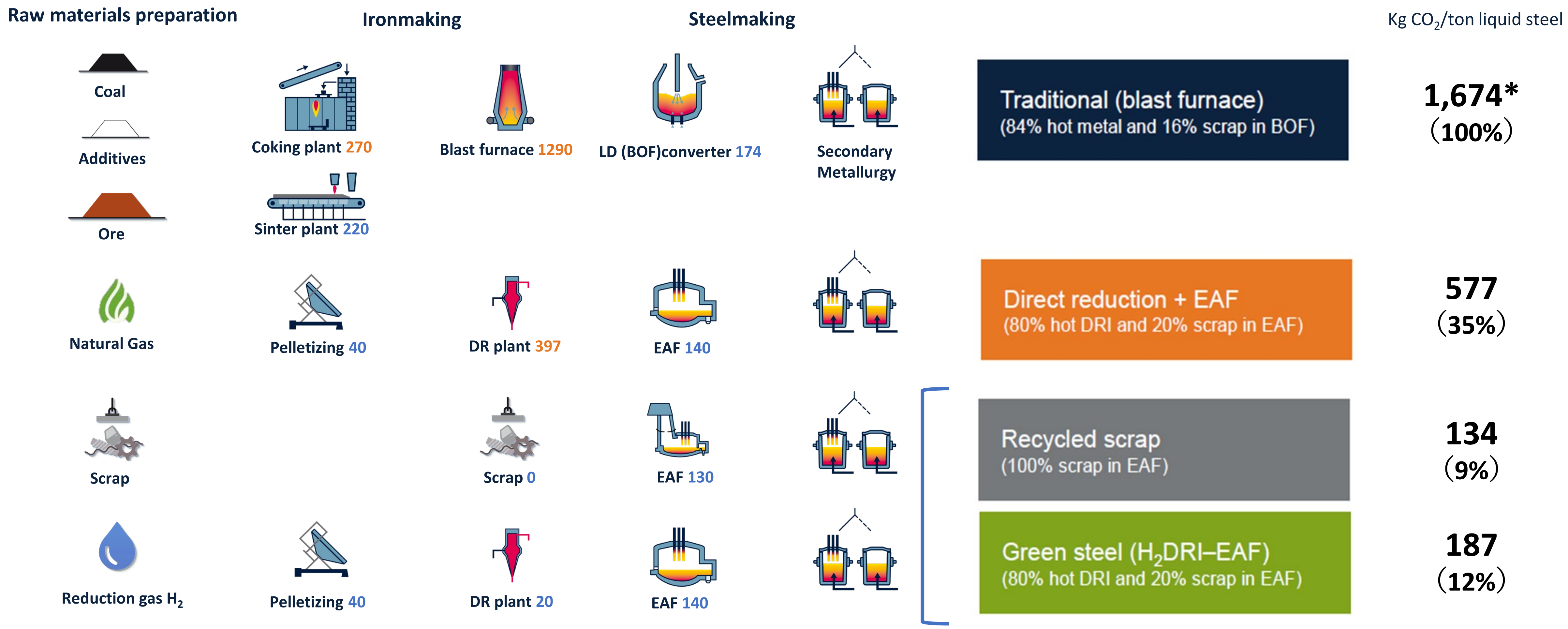
  : In addition to the new technologies under development, current production processes will likely continue to be used in some situations (e.g. to afford different ore grades).

- To focus on Steel industry and CCUS from an equipment supplier's viewpoint.

WORLD MATERIALS FORUM

2. Steel Industry from an Equipment Manufacturer's Viewpoint

1) Varied CO2 Emissions depending on the Routes of Steel Production



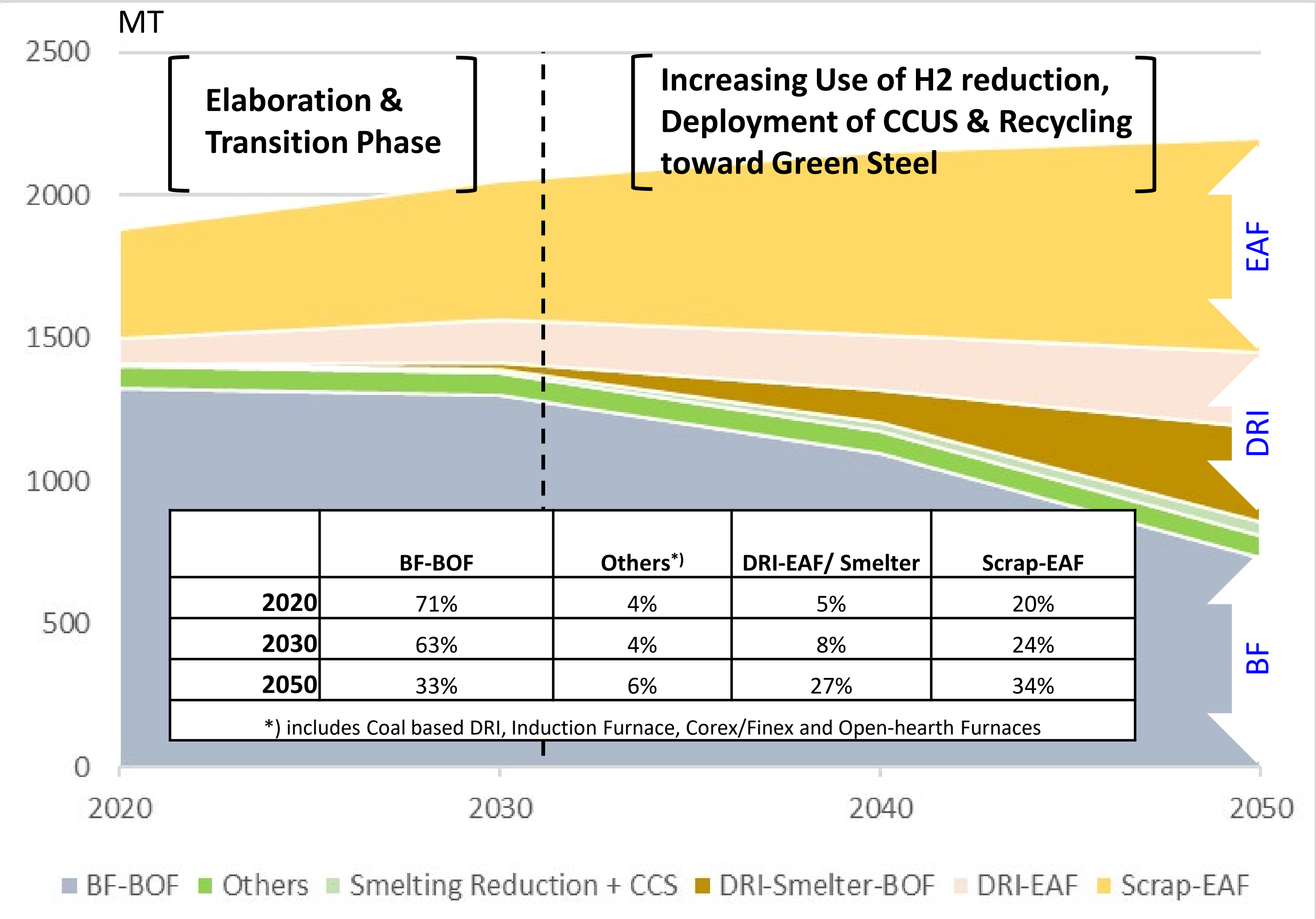
*Based on BAT and includes credits for slag and gas utilization(-280kg/CO2ton)

All figures based on emission factor of **80 g CO_2** / kWh (IEA forecast after 2030)

2. Steel Industry from an Equipment Manufacturer's Viewpoint

2) Possible Range of Steel Making Technologies toward Decarbonization

[Assessment and forecast by Primetals Technologies]



	BF-BOF	Others*)	DRI-EAF/ Smelter	Scrap-EAF
2020	71%	4%	5%	20%
2030	63%	4%	8%	24%
2050	33%	6%	27%	34%

*) includes Coal based DRI, Induction Furnace, Corex/Finex and Open-hearth Furnaces

Less or no use of carbon for reduction

- DRI (HBI) with increased use of hydrogen, but still needs high/medium quality iron ore
- Scrap: Reduction not required.

Remaining BF's advantages

: Able to accommodate low/medium quality iron ore, while complying with all steel grade requirements

3. CCUS as All-round Supporting Technologies

(1)Technologies' Present and Future

	Present	Future
CO_2 Capture (CC)	- Various proven technologies : Chemical Absorption Process : Solid Adsorption Method : Membrane Separation Method	- Extend applications to many industrial processes and facilities emitting CO_2 - Develop compact and modular CC systems to be developed
Utilization (U)	- Direct use of CO_2 such as for Urea production and EOR* - Indirect use of CO_2 (methanol and the like by conversion)	- Technologies of both direct/ indirect use of CO_2 to improve economics, expanding applications such as SAF*
Storage/ Sequestration (S)	- Feasibility study and/or demonstration plant stage - Compression/Transportation costs need to be lowered	- With incentives, viable projects to be realized in areas appropriate for storage

*Enhanced Oil Recovery

*Sustainable Aviation Fuel

3. CCUS as All-round Supporting Technologies

(2) Technologies Highlights : CO2 Utilization Plants supplied by MHI

Urea Production

In UAE 400t／day

EOR (Enhanced Oil Recovery)

Petra Nova Carbon Capture EOR 4776 t/day

3. CCUS as All-round Supporting Technologies

(3) CCS – Feasibility Study for Lehigh Cement

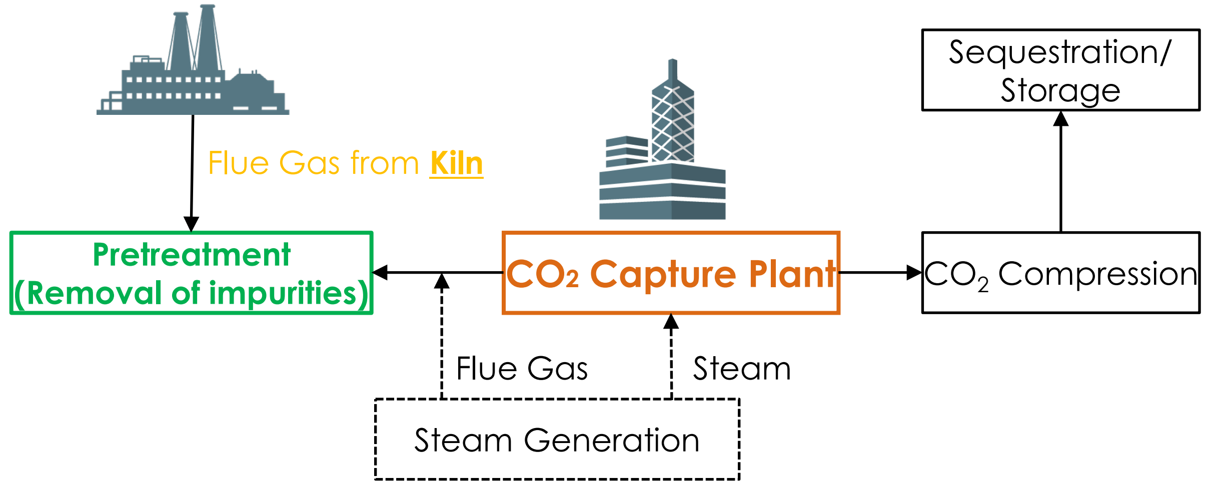
Lehigh Cement

Purpose

- Advancing low carbon in cement industry
- CCS on cement plant in **Edmonton, Alberta**
- Looking at the viability of capturing **90-95%** CO_2 (estimated **600,000tpa**)
- Co-study with **International CCS Knowledge Centre**
- Funded by **Emissions Reduction Alberta*** (local government)
  * invests innovative science and engineering that propels GHG reduction
- Contributing to **Canada Climate Plan**

Block Flow Diagram

- Flue gas from **Kiln**
  (over **90%** of CO2 from Cement Plants)
- Optimization to **impurities** specific to cement plant



4. Summary

(1)Multiple Pathways - an Inevitable and Pragmatic Approach

: To cope with different conditions of countries in their respective economies, availabilities of energy and resources as well as technological/industrial capacities.

(2)CCUS - critical technologies for facilitating a complete Decarbonization of Bulk Material

: Complementary function to such new technologies that reduces CO2 emission in production processes of major bulk materials like steel, cement, aluminum.

Appendix: MHI's Takasago Hydrogen Park

- **A one-stop-shop for validating hydrogen-related technologies from hydrogen production to power generation**
- **Test and validate water electrolysis, turquoise hydrogen*, SOEC** and other technologies in-house and improve product reliability**

  *Turquoise hydrogen: H_2 obtained through pyrolysis of methane into H_2 and solid carbon

  **SOEC (Solid Oxide Electrolyzer Cell): High temperature steam electrolysis
- **Make progress toward establishing a hydrogen solutions ecosystem, which will help achieve a sustainable society by linking various industries with hydrogen technologies**
- **Validate hydrogen gas turbine technology**