



Direct Reduced Iron (DRI) and CO₂ Capture

(Review of Current State of the Art)

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Meeting with European Commission

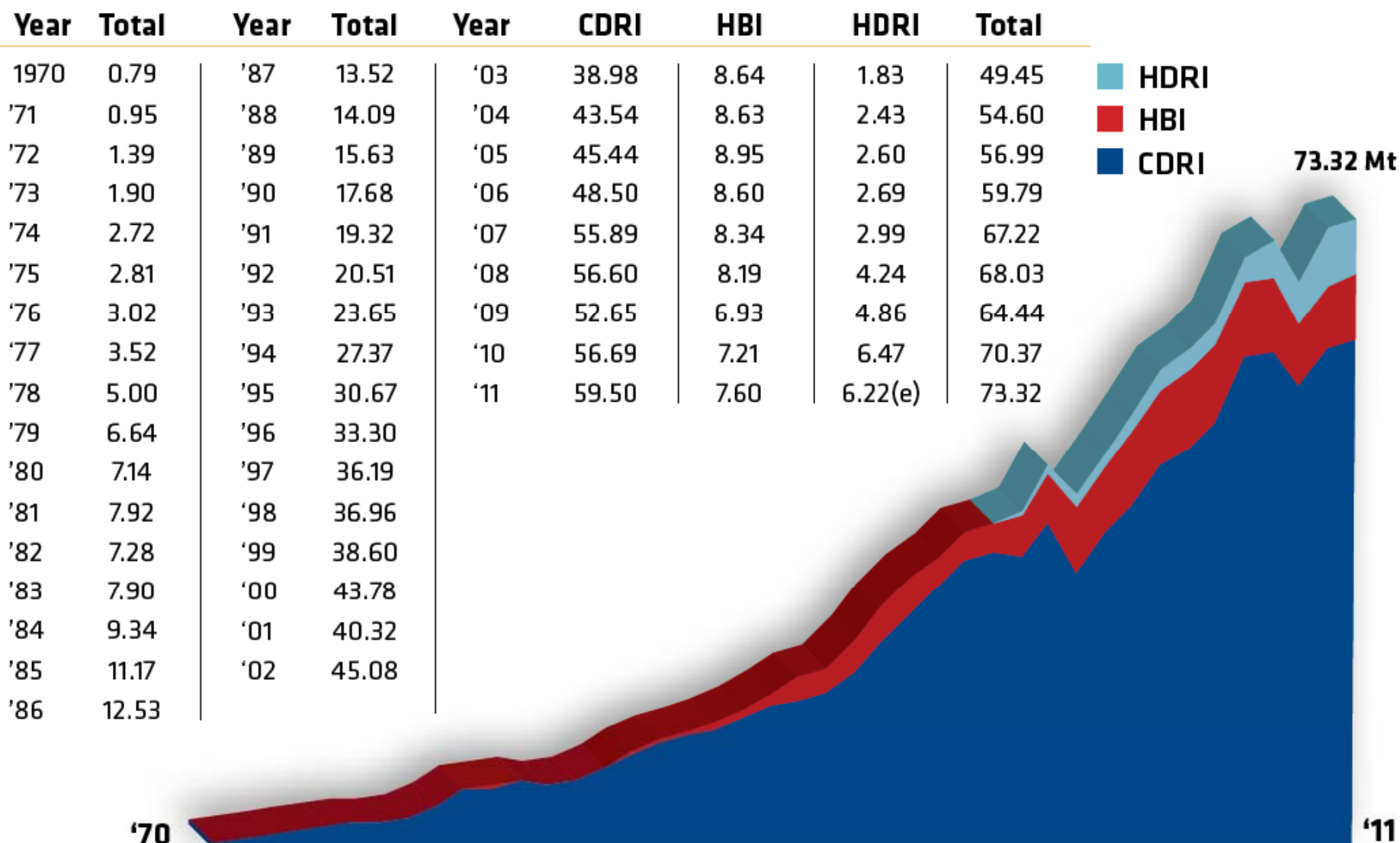
13th July 2012



Presentation Outline

- ***Background***
- ***Gas Based - Direct Reduced Iron***
 - Midrex
 - Hyl-III and Hyl-ZR
 - ULCORED
- ***Hybrid System***
 - Corex-DRI Scheme
 - Gasification-DRI Scheme
- ***Coal Based – Direct Reduced Iron***
 - SL/RN
 - ITmk3
 - Others...

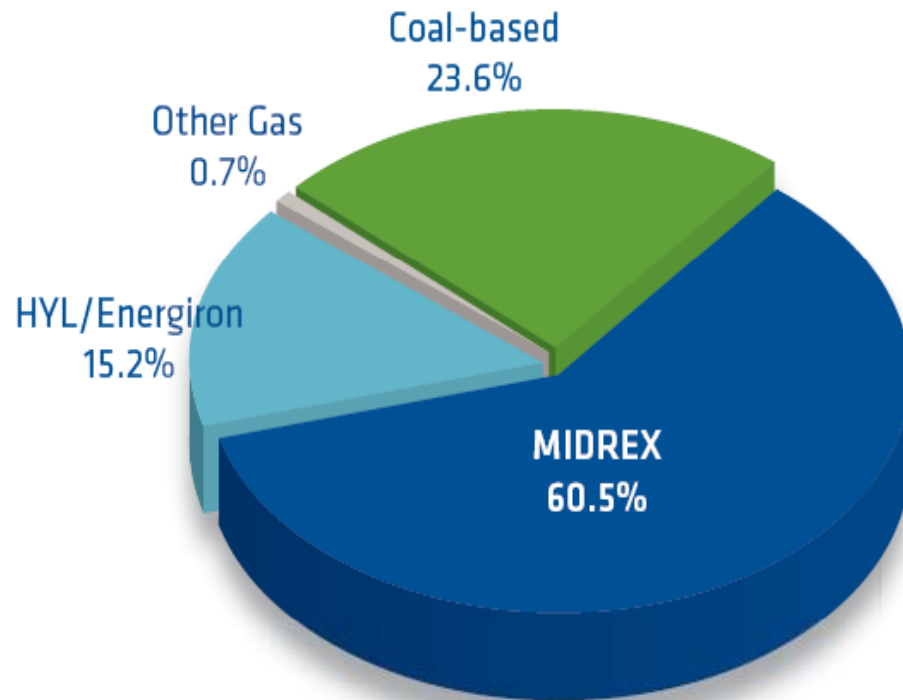
Background



Background



2011 World DRI Production by Process



Total World Production: 73.3 Mt

	2009	2010	2011
MIDREX	59.9%	59.7%	60.5%
HYL/Energiron	12.4%	14.1%	15.2%
Other Gas	0.8%	0.5%	0.7%
Coal-based	26.9%	25.7%	23.6%

Source: Midrex Technologies, Inc.

Background



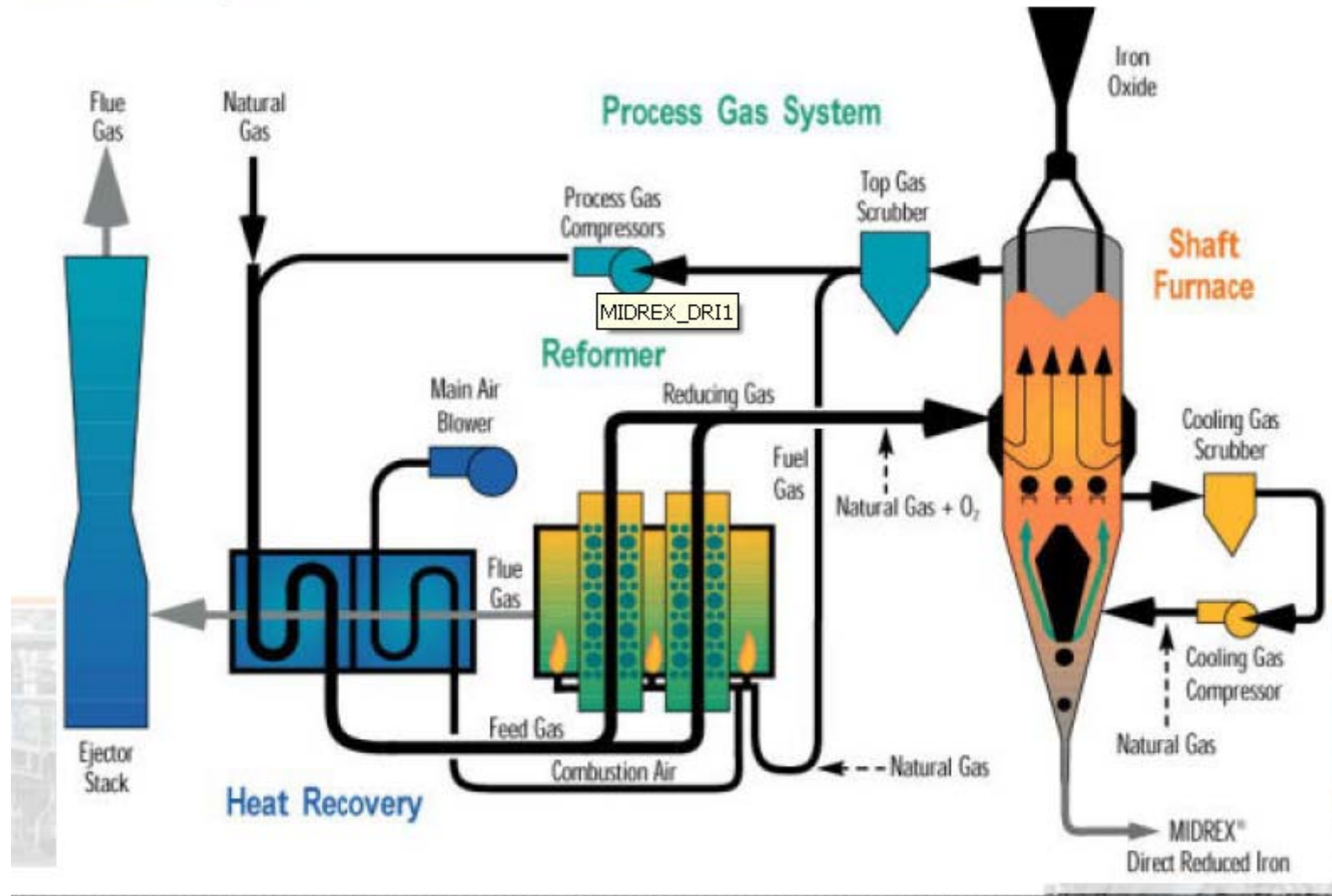
- ***Product***

- Hot Briquetted Iron (HBI)
- Cold Directly Reduced Iron (c-DRI)
- Hot Directly Reduced Iron (h-DRI)

- ***In addition to good alternate to scrap, it is a potential raw material input to Blast Furnace could lead to reduction of CO₂ emissions. (i.e. reduced coke, sinter requirement)***

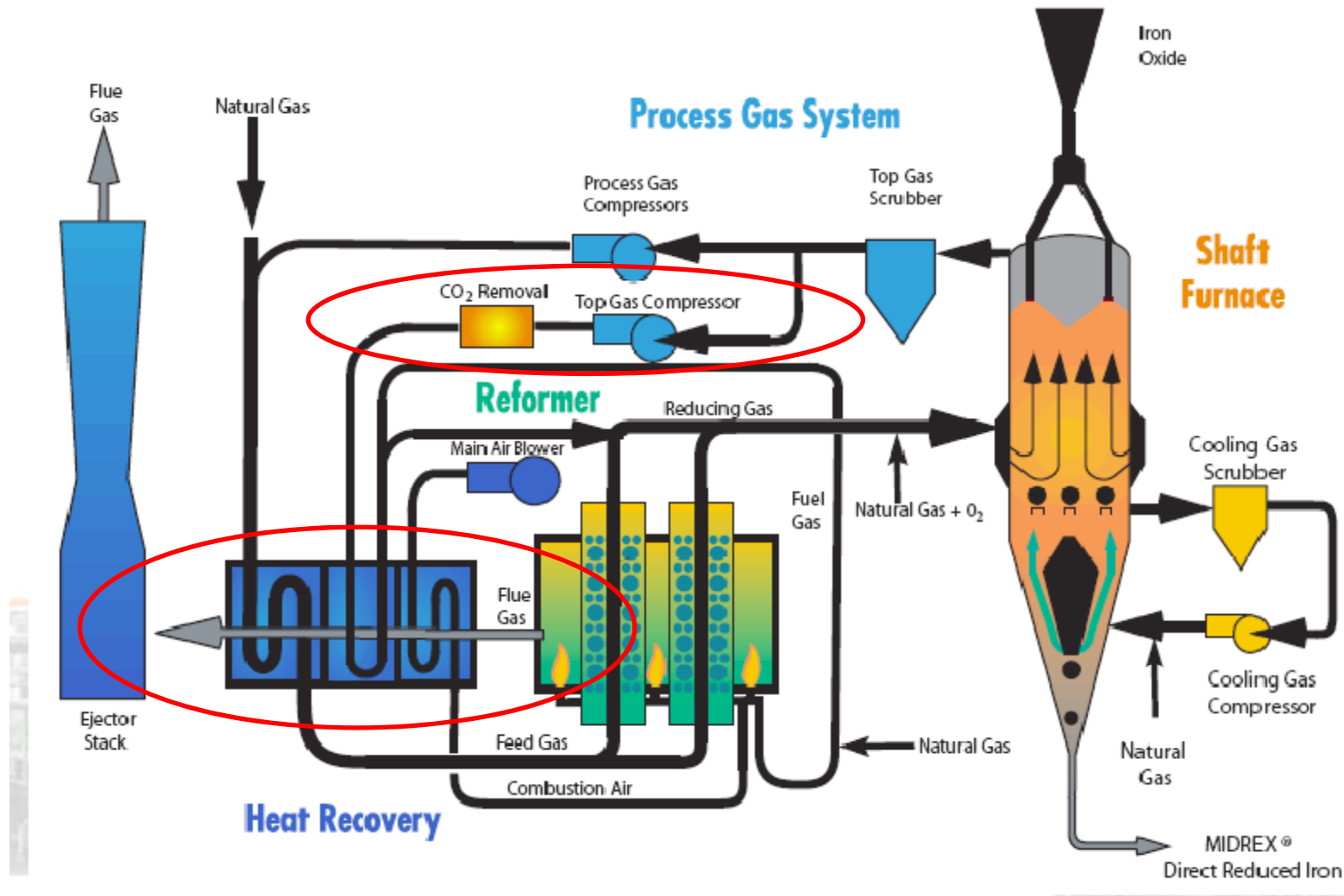
Midrex

(Conventional without CO₂ Capture Option)



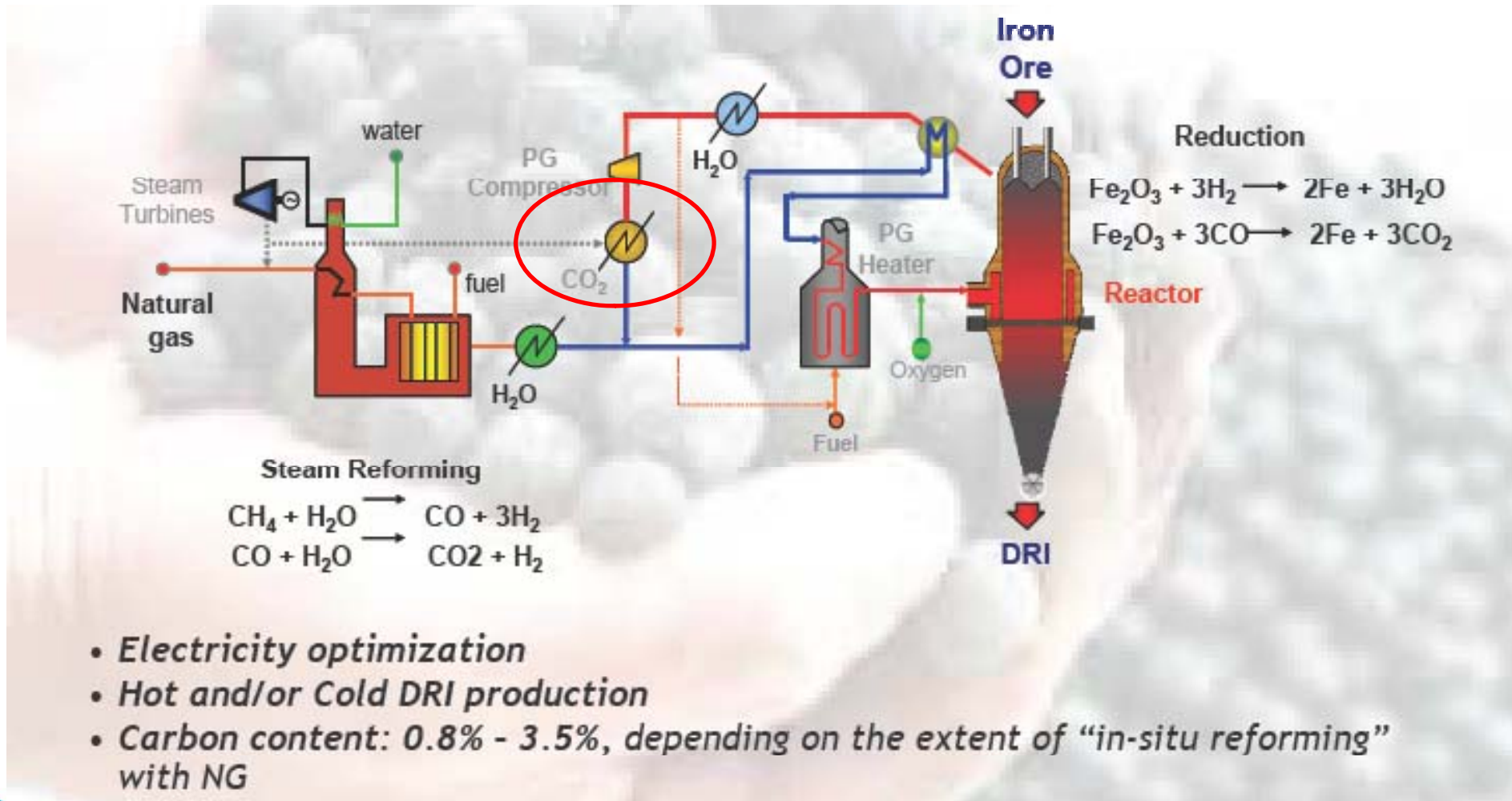
Midrex

(Conventional with CO₂ Capture Option)



HYL-III (Energiron DR)

Plant Configuration with SMR



- *Electricity optimization*
- *Hot and/or Cold DRI production*
- *Carbon content: 0.8% - 3.5%, depending on the extent of “in-situ reforming” with NG*

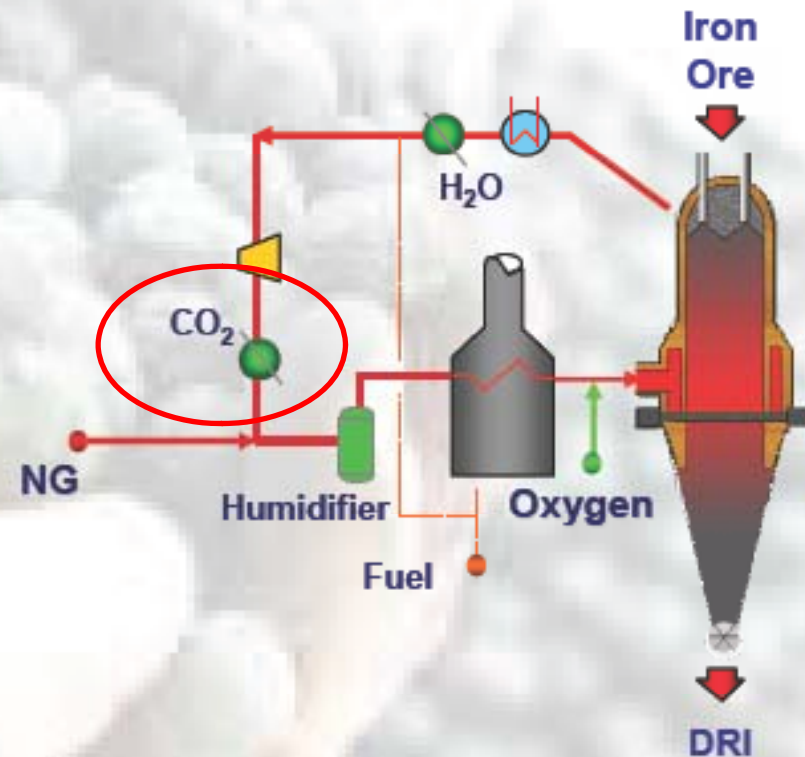
HYL-ZR (Energiron ZR-DR)

Plant Configuration without Reformer



- **The Scheme w/o Reformer is characterized by the following features:**

- ✓ Partial combustion of the reducing gas.
- ✓ “In-situ” reforming of CH_4 in the lower part of the reactor's reduction zone.
- ✓ Adjustable composition of the reducing gas to control DRI metallization and carbon.
- ✓ *Natural gas optimization*
- ✓ *Hot and/or Cold DRI production*
- ✓ *Carbon content: 2.0% – 4.0%*



CCUS Application

(Currently Operational)



- ***Arcelor Mittal – Lazaro Cardenas (Mexico)***
 - HYL-III Technology (4 x 0.5 mtpy c-DRI)
 - Upgraded in 2007 to include CO₂ capture – Sold to food industry (Operational since 2008)
- ***Welspun Maxsteel – Raigad (India)***
 - HYL-III (0.9 mtpy DRI/HBI) and HYL-ZR (0.55 mtpy DRI/HBI)
 - Upgrade & New Build in 2006. (Operational since 2008)
 - Capture of CO₂ from HYL-ZR – Sold to food industry.



CCUS Application

(Under Construction or In Planning)

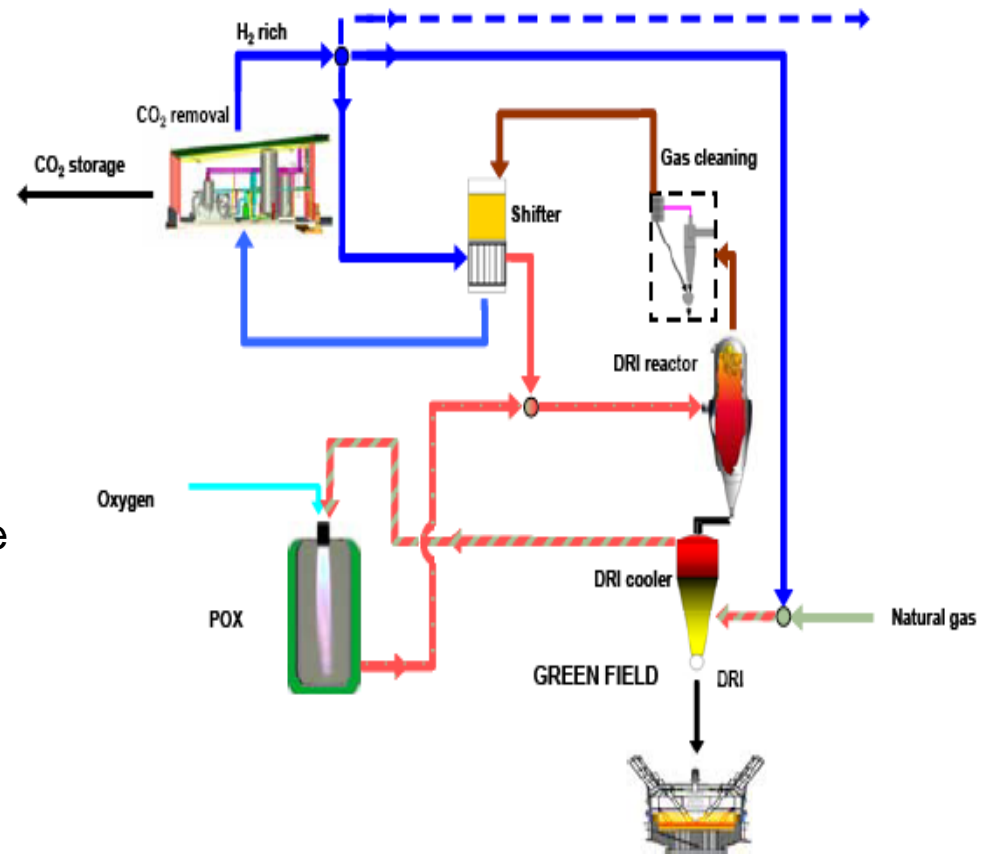
- ***Emirate Steel - Abu Dhabi (UAE)***
 - HYL Energiron DR (2 x 1.6 mtpy h-DRI)
 - Upgrade for CO₂ Capture for EOR application (Expected by 2013/2014)
- ***Nucor – Louisiana (USA)***
 - HYL Energiron ZR (1 x 2.5 mtpy c-DRI)
 - Under construction – operational by 2014/2015
 - With CO₂ Capture for EOR application
 - Note:
 - Original permit – was to build a BF/BOF integrated steel mill. But due to Shale Gas, Nucor switch DRI plant.

ULCORED Technology

(Information from ULCOS)



- **Claimed to reduce 20% energy consumption as compared to other DRI Technology.**
- **Key Features**
 - 100 % use of oxygen instead of air
 - Based on partial oxidation. POX, reactor instead of a reformer
 - With CO shift reactor to convert CO to H₂ and CO₂ – therefore maximise CO₂ removal
 - CO₂ cleaning of the off gas stream after shifter by
 - pressure swing adsorption, PSA/VPSA or amine wash to produce a clean CO₂ for storage and a hydrogen stream to be recycled to the reactor

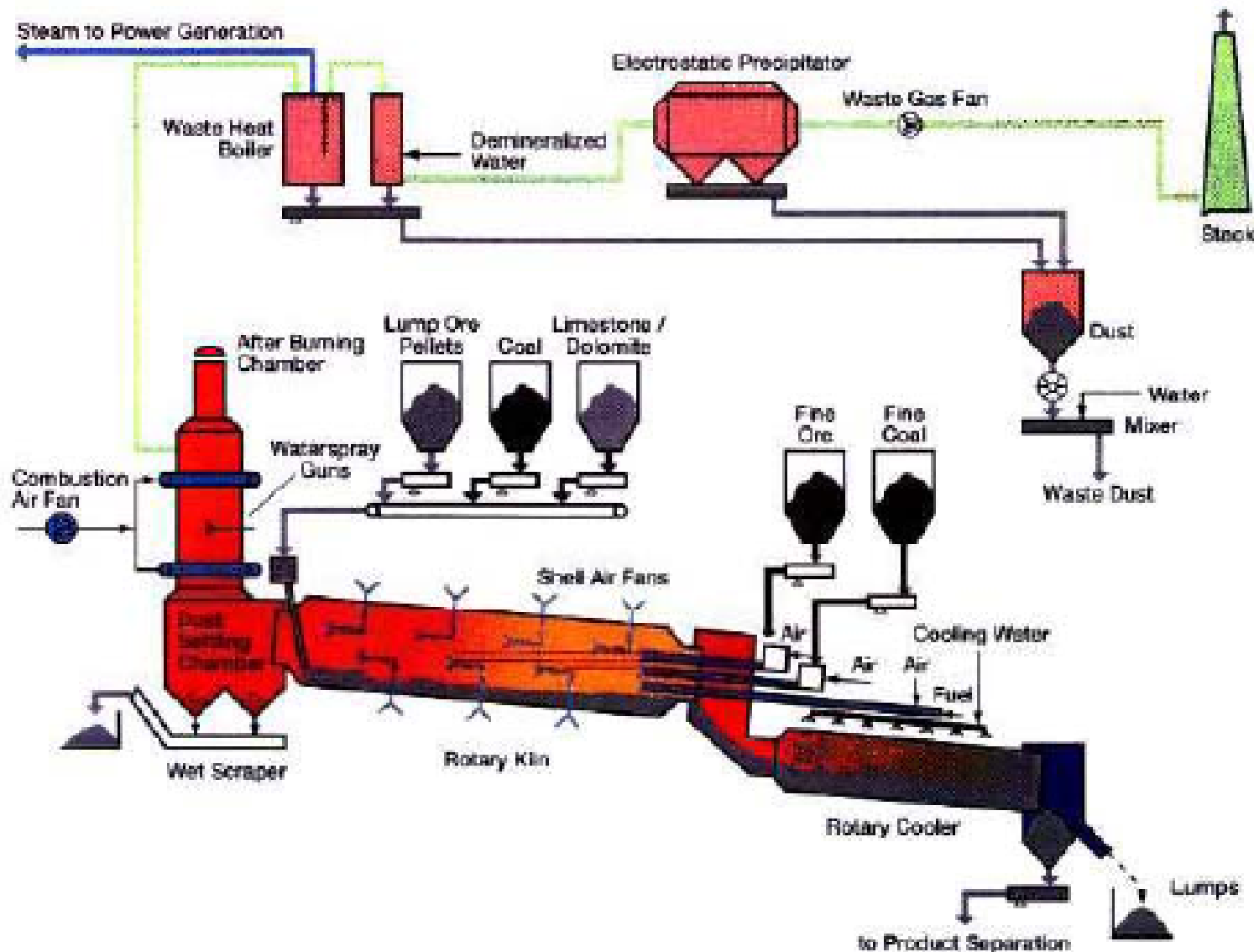


Coal Based DRI -

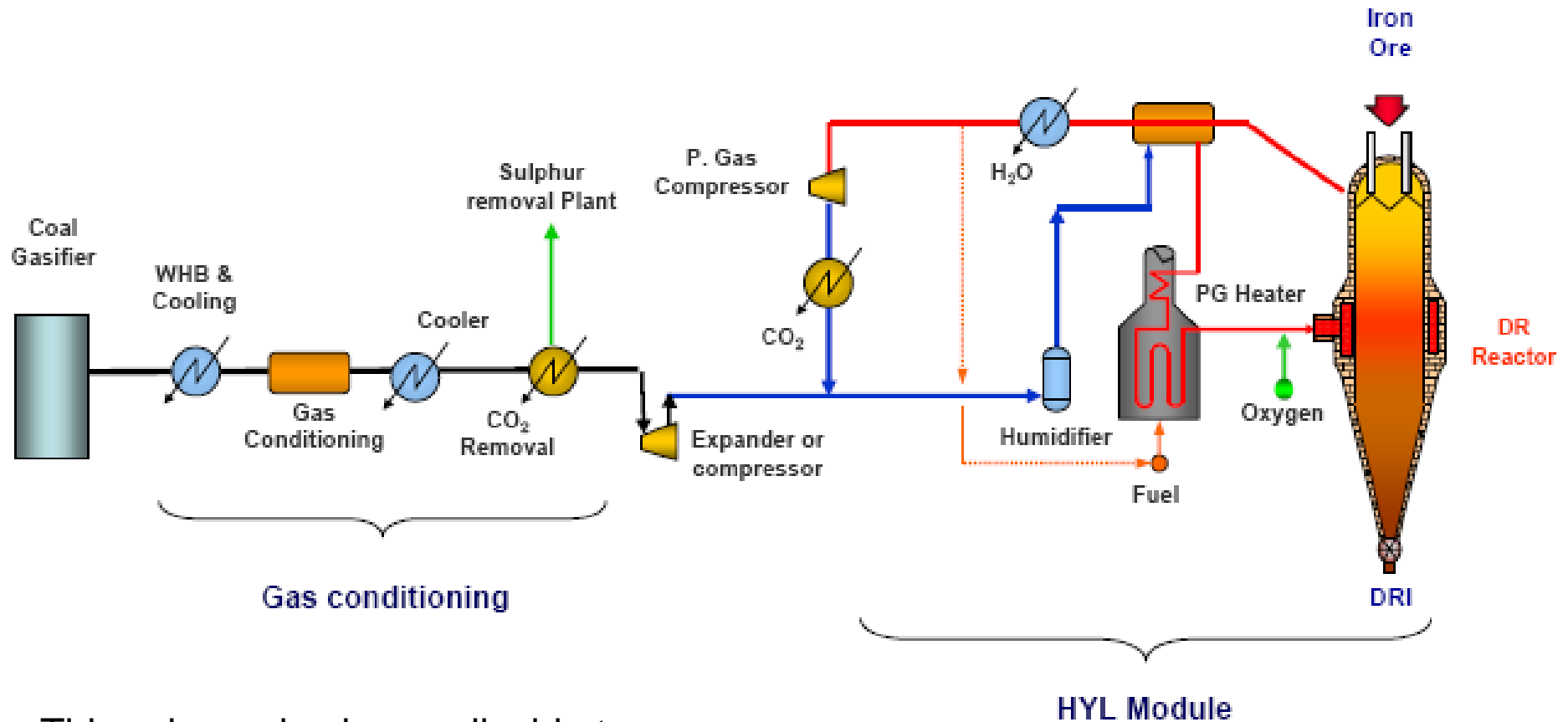


- ***SL/RN – Rotary Kiln with Rotary Cooler***
 - Status – Commercially Operated
 - Largest Capacity ~0.3 mtpy per module
 - Issue with Pollutant Emissions
 - India (22 units), South Africa, Brazil
 - Not considered viable to incorporate CO₂ capture

SL/RN Process Configuration



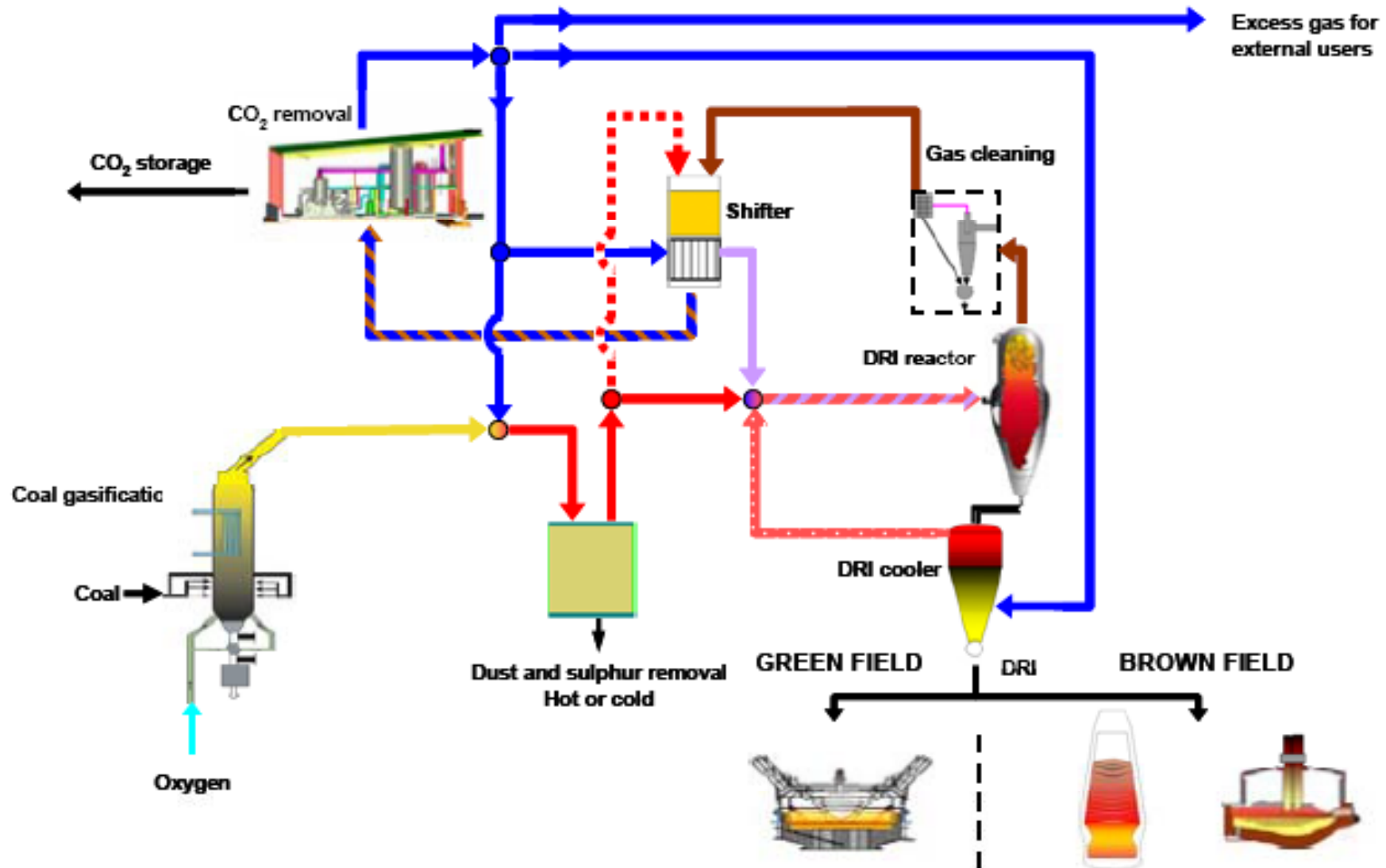
Gasifier – DRI Scheme



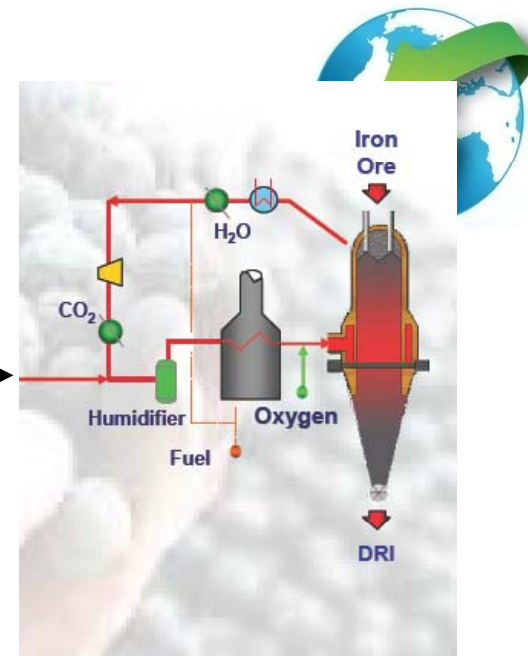
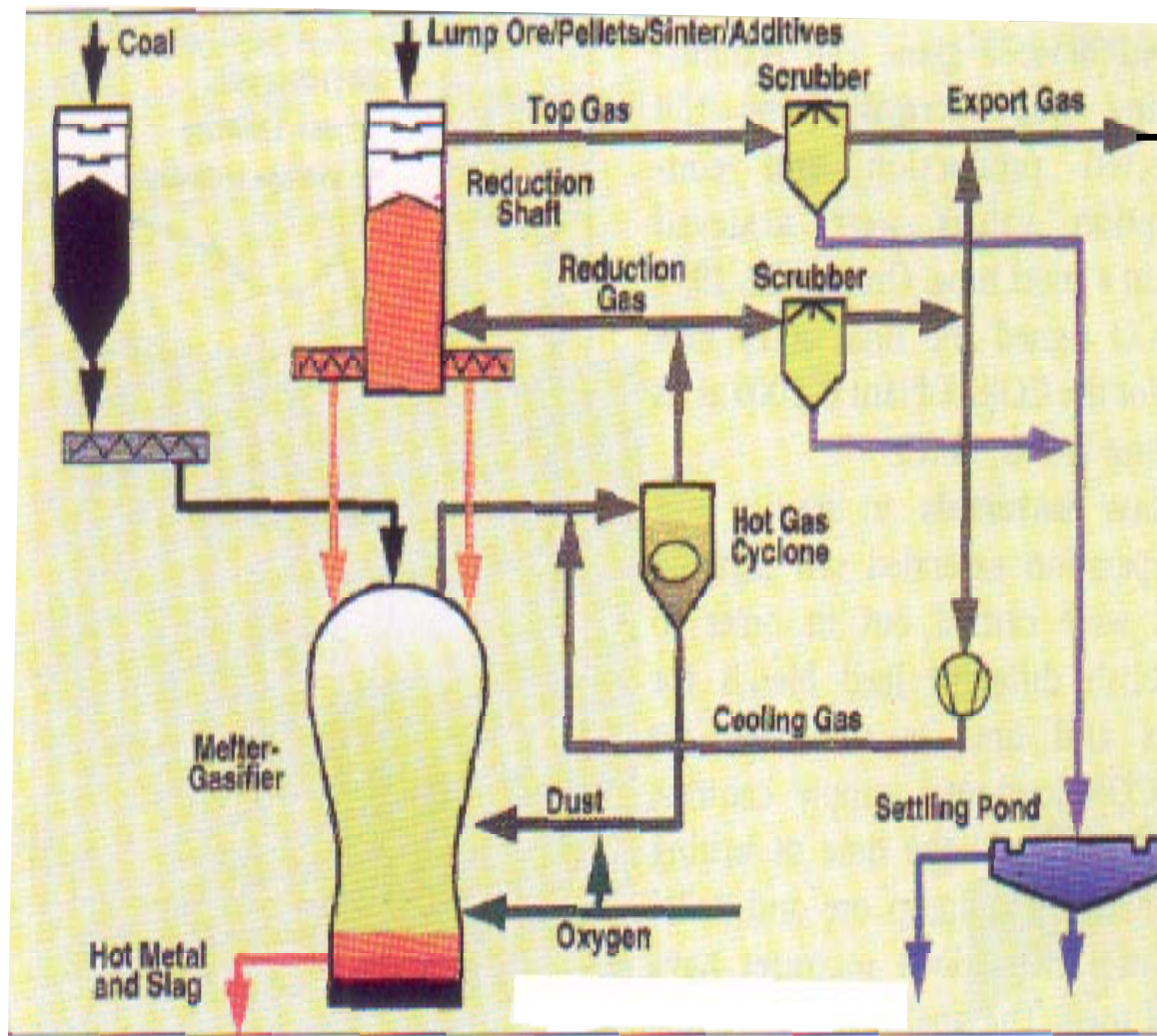
This scheme is also applicable to

- Midrex Technology

ULCORED Coal Based DRI



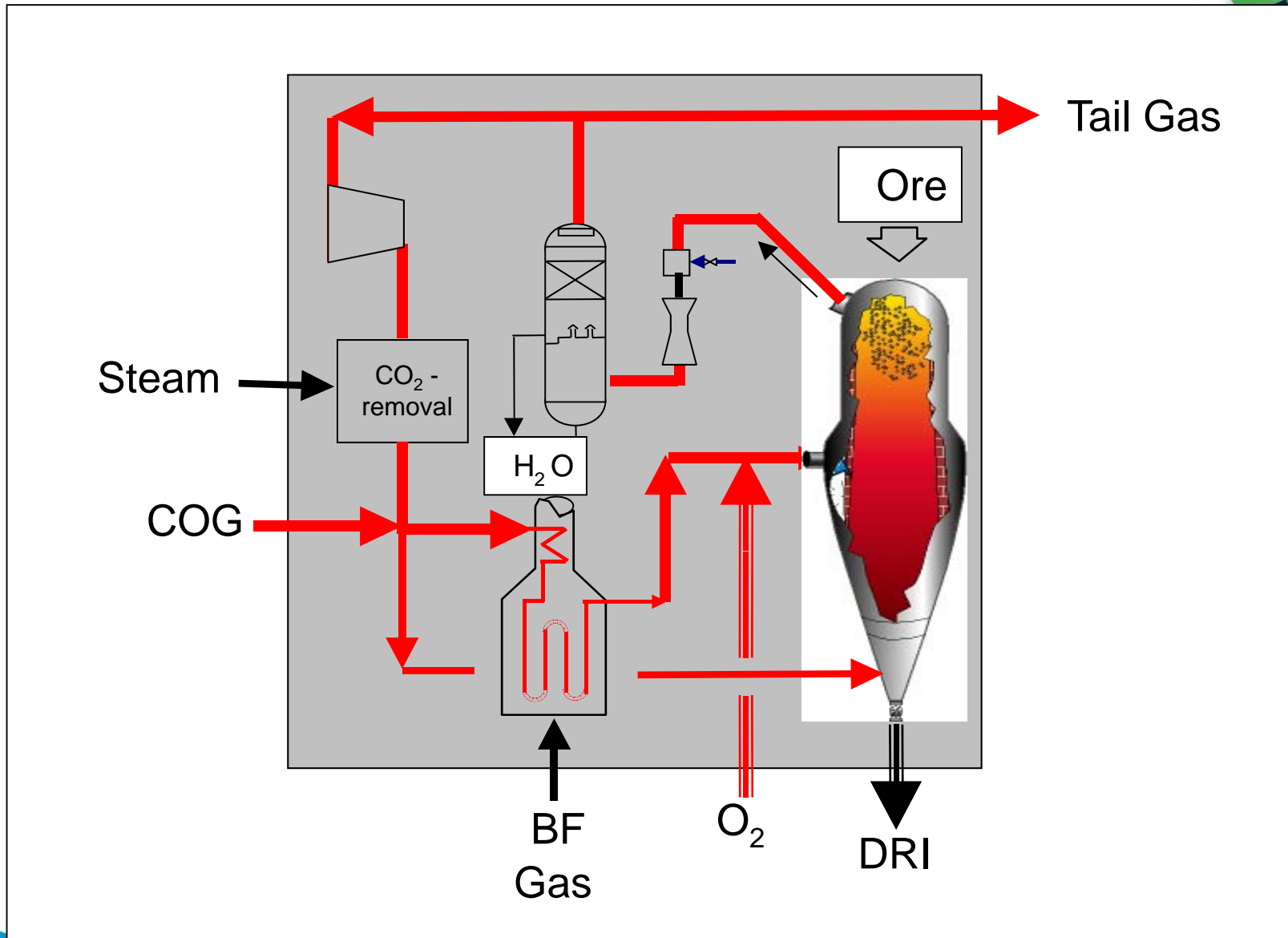
COREX-DRI Scheme



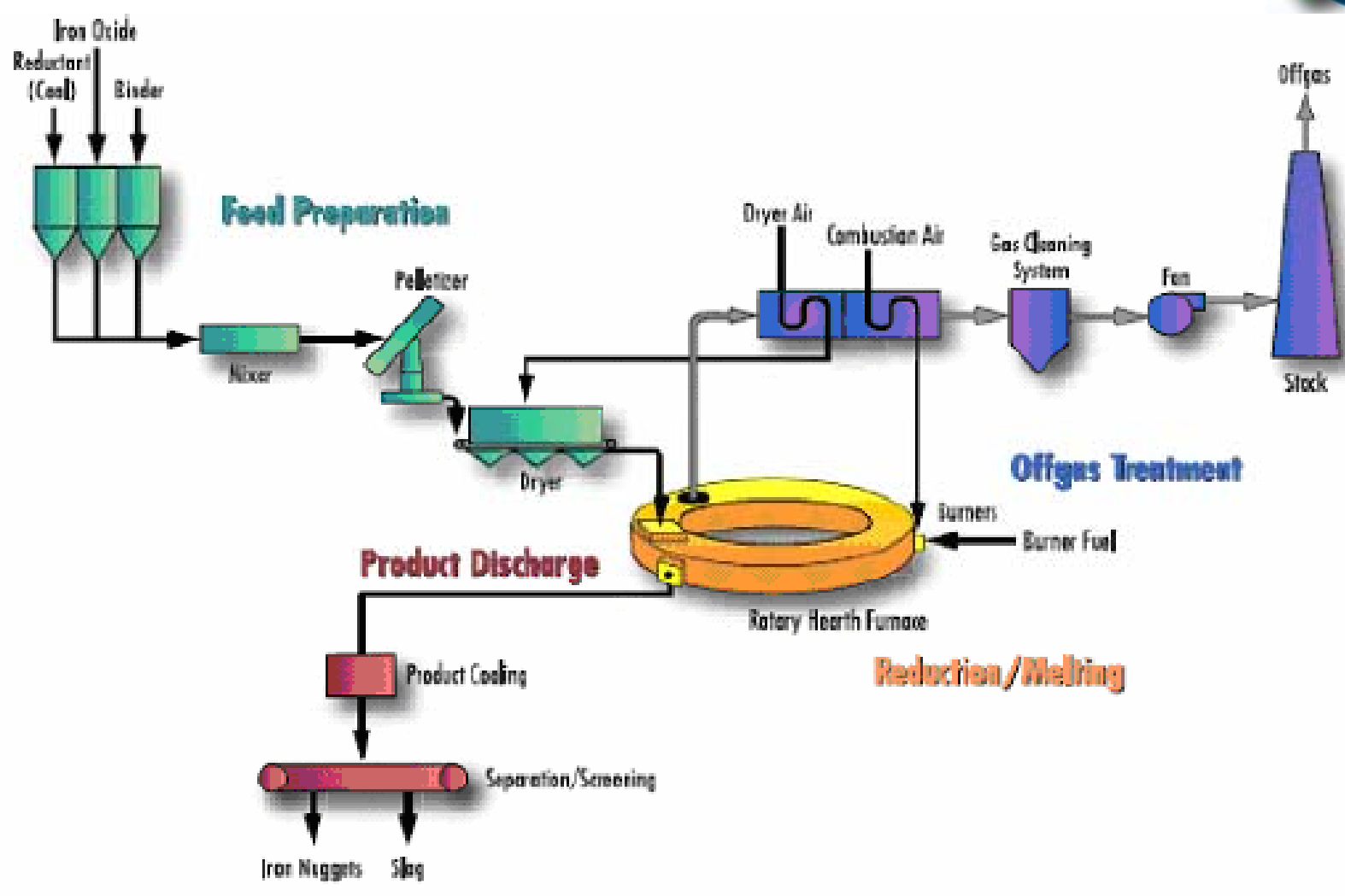
This scheme is applicable to

- Midrex Technology
- HYL Technology
- ULCORED Technology

COG – DRI Scheme



ITmk3 – Iron Nuggets



Fuel: Coal

Feed: Fine Ore

Concluding Remarks



- ***Different CO₂ capture options for production of DRI/HBI or other iron sources to steelmaking has been reviewed.***
- ***Expected growth in Gas Based DRI/HBI Production.***
 - As important source of metal alternate to scrap steel in EAF production
 - Could be a good substitute metal input to the Blast Furnace (therefore reducing coke consumption)
- ***Growth in coal based DRI/HBI should be expected in India where coking coal supply is limited.***