ENERGIRON HYL

THE INNOVATIVE DIRECT REDUCTION TECHNOLOGY

Energiron Technology Flexibility For Adapting to Indian Conditions: Micro-Module and Gas Alternatives

Metal Bulletin/Metal Junction Conference

Emerging Steel Scenario - focus Orissa

September 27-28, 2007

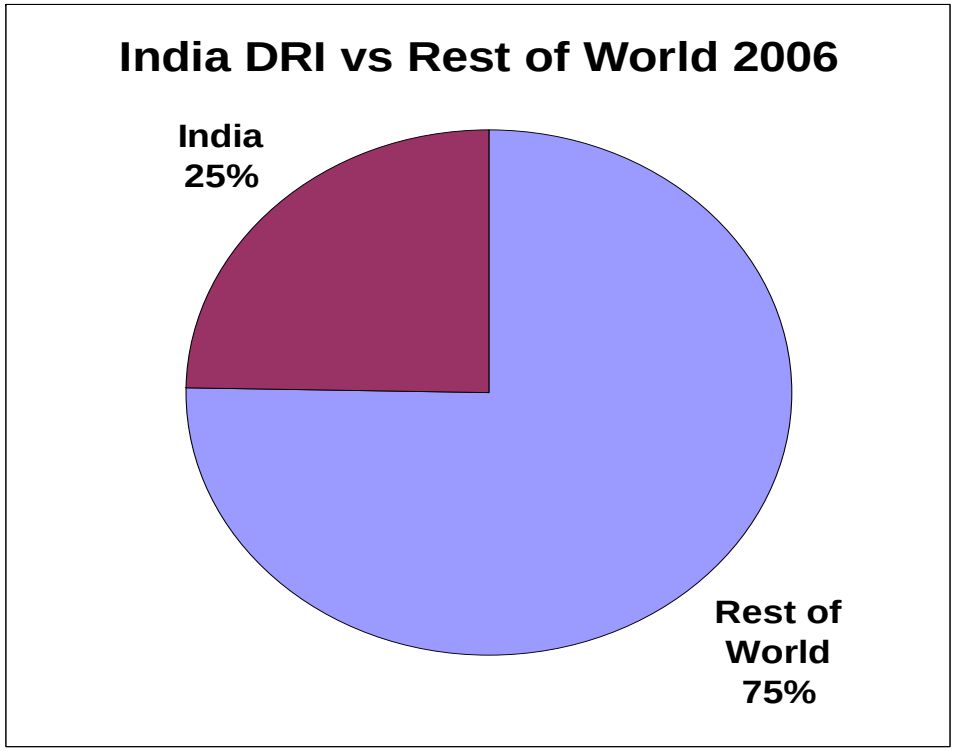
Overview

- The current size and future potential of the Indian DRI (sponge iron) industry will be conditional to both availability of reductant sources and compliance with environmental standards.
- While the dominant scheme in India is coal based technology, the imminent need to modify these plants and processes to make them more environmentally friendly will significantly increase their capital costs.
- In the medium term, natural gas availability in various regions of India could provide a clean reducing gas alternative to coal processes.
- Tenova HYL and its associates in India, Electrotherm India, Ltd., can currently provide small scale DRI producing plants adapted to Indian market conditions, which can be fueled not only by natural gas, but also by using off-gases from other sources as well as syngas produced from gasification of low-grade coal.

Indian DRI Production 2006

Total World Production 2006

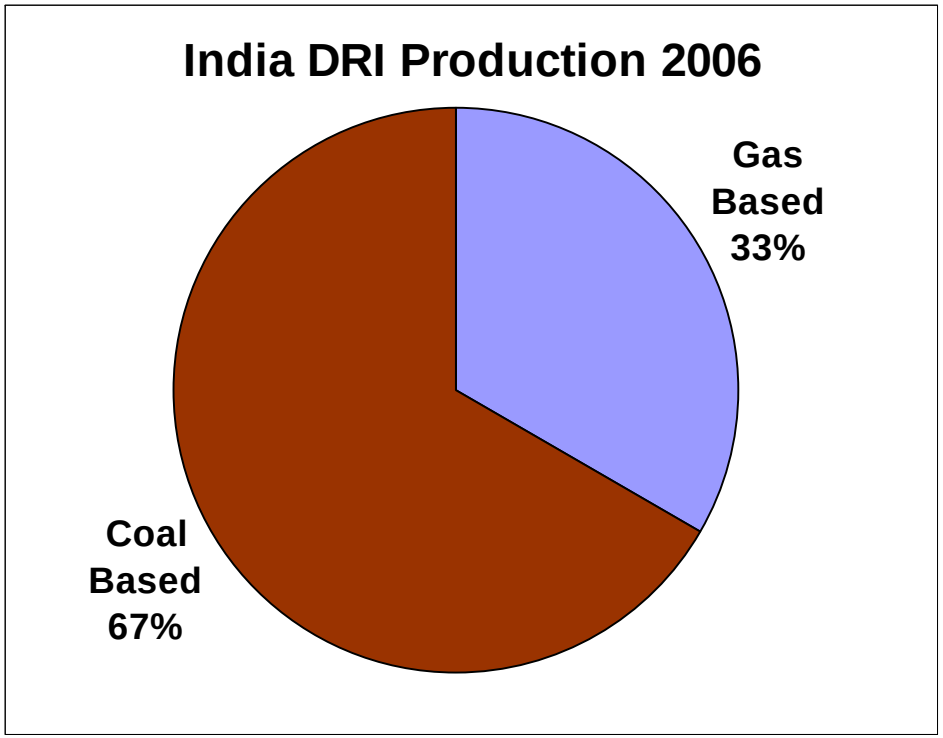
59.79 Million tons



Total India DRI Production 2006

14.74 Million tons

- 9.88 Million tons via Coal based
- 4.86 Million tons via Gas based



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Coal-based vs Gas-based

- Some 200 coal-based plants in India have a total capacity of 24 million tons/year.
  - ✓ Actual production is only around 41% of cap.
- Gas-based plants in India have a total capacity of 5.57 million tons/year.
  - ✓Actual production is **87%** of cap.
    - Due to lack of gas availability, otherwise 100%+

Coal-based technologies

- Advantages
  - ✓ Low capital cost
  - ✓ Use of abundant coal as reductant
- Main disadvantages …
  - DRI is lower quality (low metallization, high gangue, ash, etc.)
    - Therefore, not suited to high-end steelmaking
  - Plants are not “environmentally friendly”
  - Cleaning up plants would greatly increase capital cost

Gas-based technologies

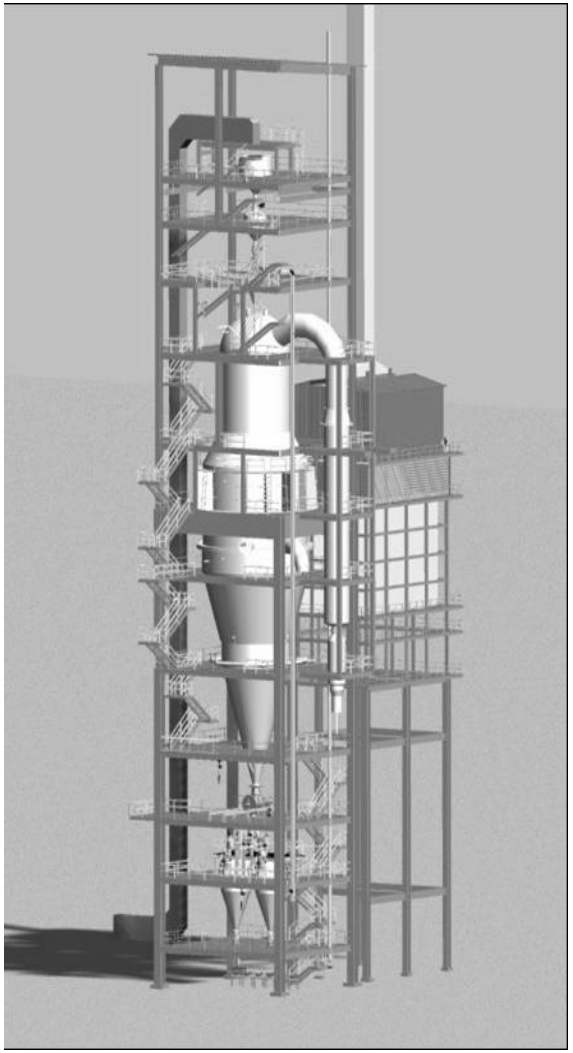
- Advantages
  - ✓ High quality DRI (high metallization & carbon)
  - ✓ Product suits best steelmaking qualities
  - ✓ Can be used onsite or as merchant product
  - ✓ Plants are more efficient, cleaner, reliable
- Disadvantages …
  - Gas in India is not readily available (yet…)
  - Higher capital cost
    - But coal-based plants will soon increase capex to be environmentally friendly, or else shut down

What to Do???

- India has abundant iron ore
  - ✓ Steps being taken to halt exports of crude ore to add value to product (pelletizing, DRI)
- India has abundant coal
  - ✓ Low grade (non-coking) coal now used inefficiently
- Natural gas is still in the future, but price will be crucial to use for DRI production

Option 1 – Micro-Module

- In regions where natural gas is or will be available, the 200,000 tpa HYL Micro-Module is a feasible option
  - ✓ Simple design, operation and maintenance
  - ✓ Can use even 100% lump ore
  - ✓ Highly metallized, high carbon DRI
  - ✓ Reformerless design gives low capital and operating costs



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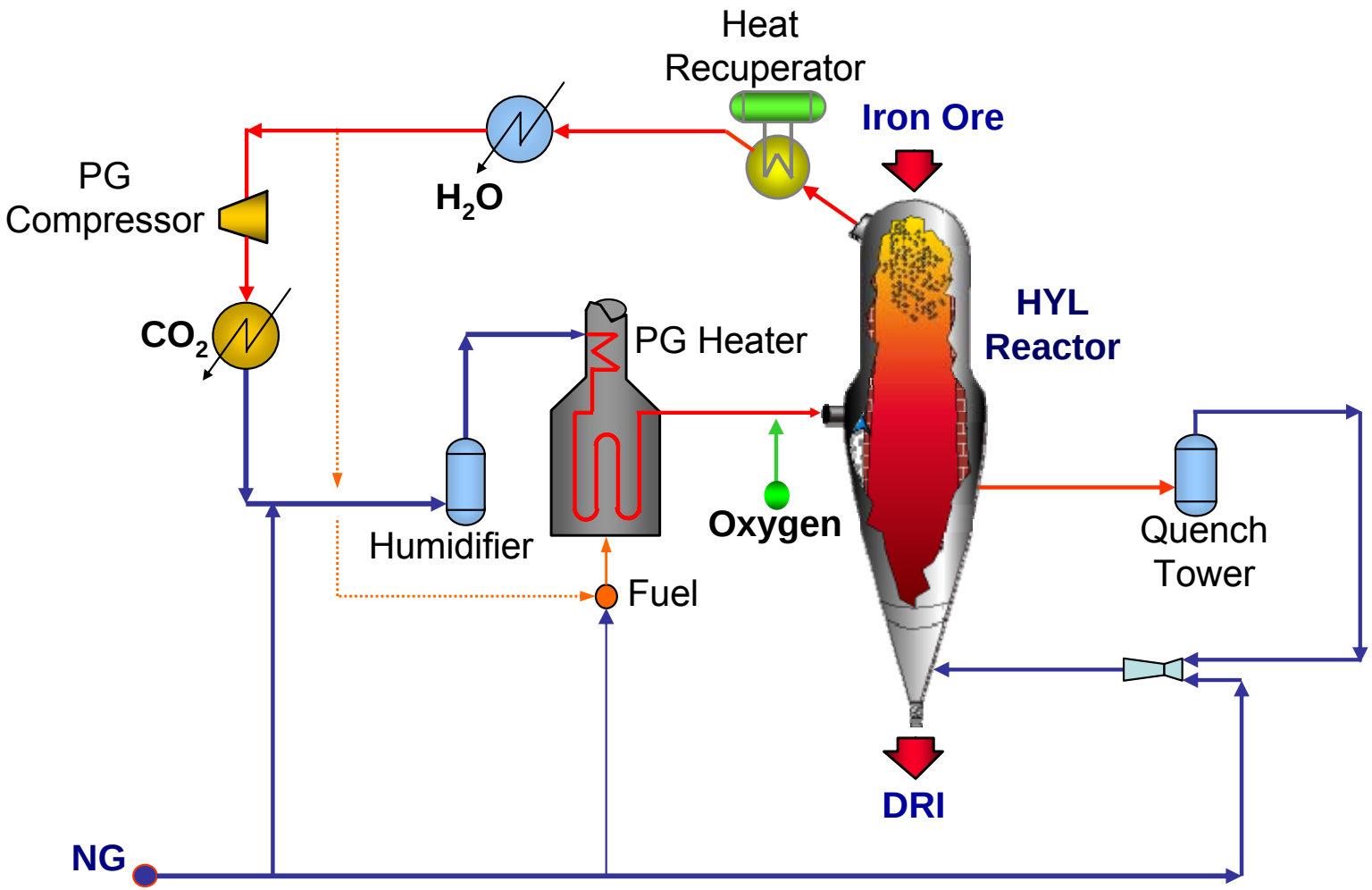
Micro-Module
ZR Process Scheme



In-situ Reforming

$CH_4 + H_2O \longrightarrow CO + 3H_2$

$CH_4 + CO_2 \longrightarrow 2CO + 2H_2$

Reduction

$Fe_2O_3 + 3CO \longrightarrow 2Fe° + 3CO_2$

$Fe_2O_3 + 3H_2 \longrightarrow 2Fe° + 3H_2O$

Carburization

$3Fe° + CH_4 \longrightarrow Fe_3C + 2H_2$

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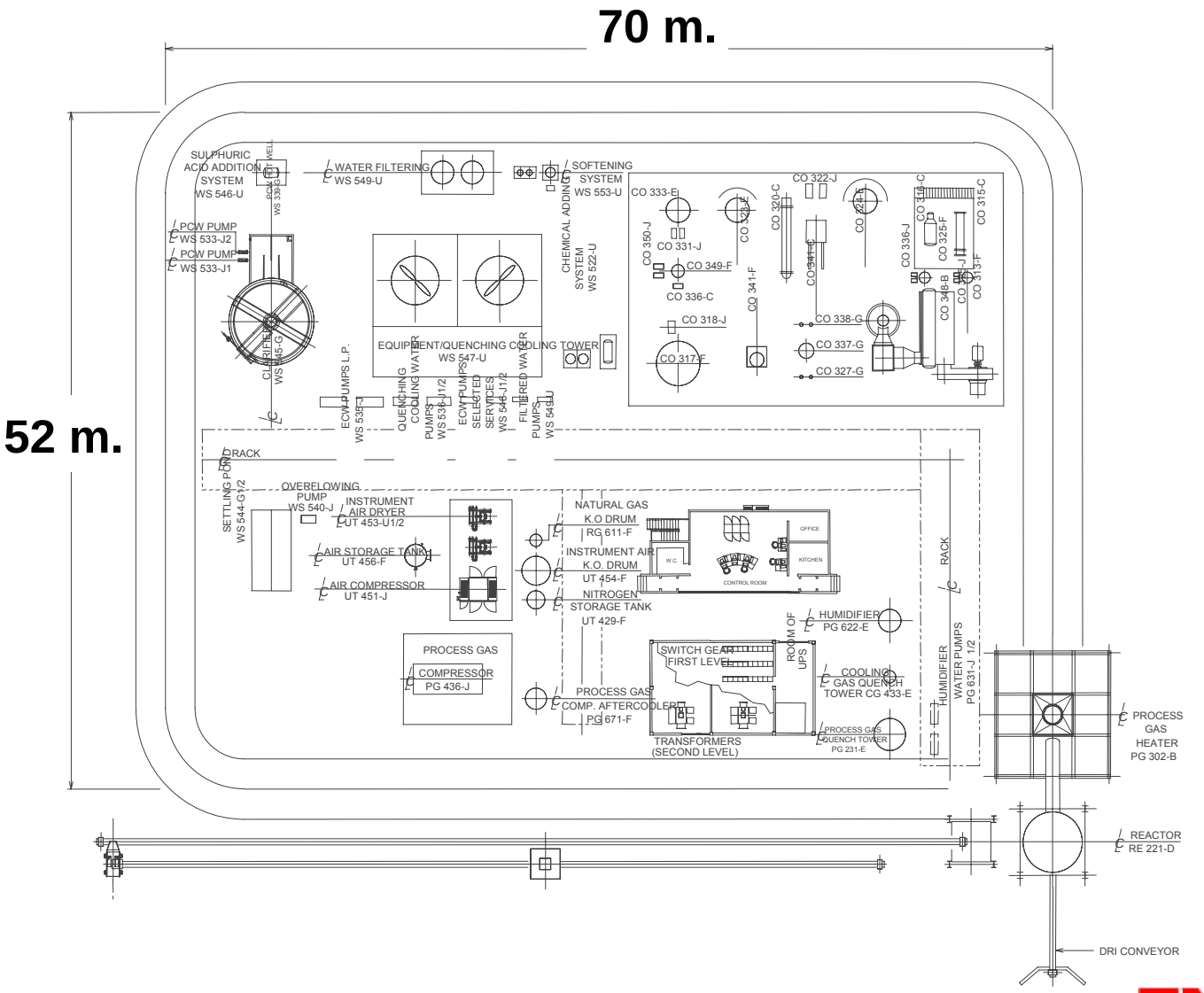
Micro-Module
Basis of Design

Product:	Cold DRI
Metallization:	93%
Carbon:	3.5%
Hourly nominal capacity:	26 t /hr
Annual Capacity	200,000 t /year
Operating hours per year:	7,800

Micro-Module Plant Layout



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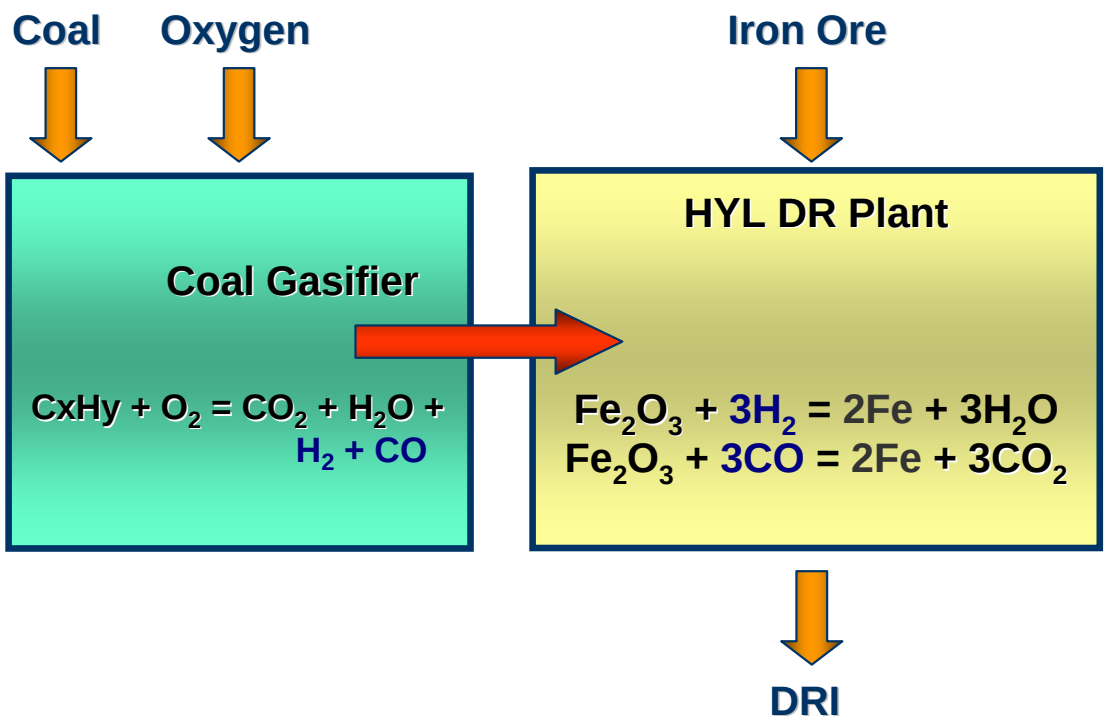
Option 2:
Coal Gasification + Energiron Plant

- No major changes or innovations.
- The reduction section of the HYL plant is unchanged.
- No technological risks involved.



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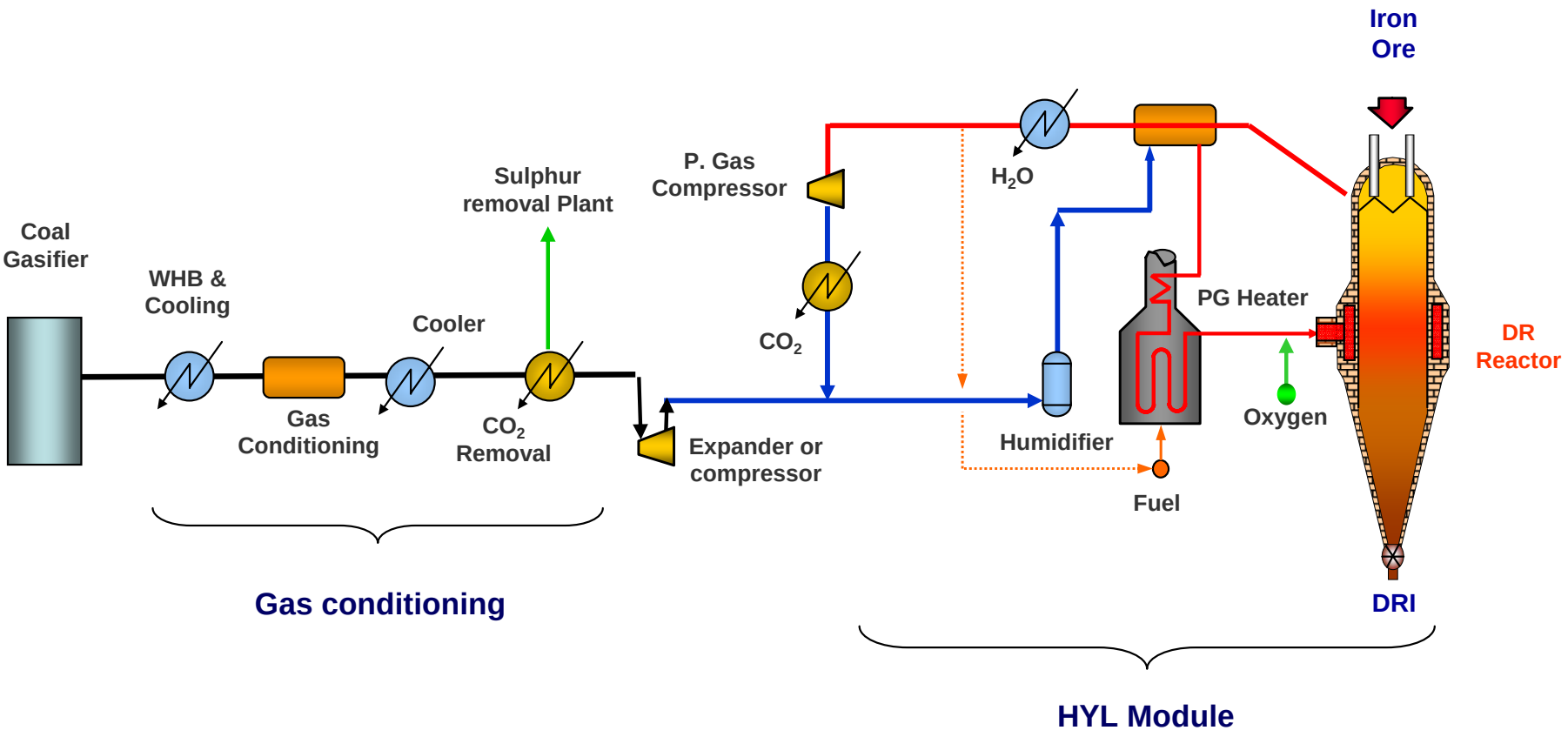
Process Scheme for Syngas



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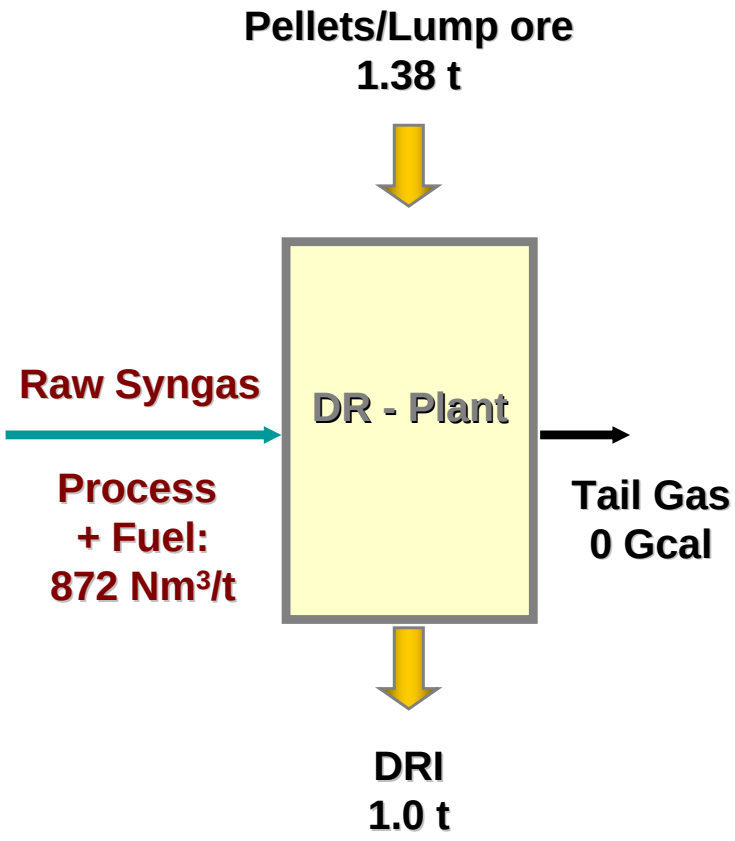
Syngas Requirement for DRI Production

Comparative Reduction Gas Analysis

Item (% volume)	Syngas Make-up	Syngas to Reactor	Reduc. gas in HYL ZR Scheme using natural gas with 100% in-situ reforming
H_2	39	54	50
CO	24	20	15
$CH_4 + C_nH_m$	10	18	25
CO_2	26	2	3
H_2O	0.3	4	4
$(H_2+CO)/(CO_2+H_2O)$		13.3	9.3
N_2	0.2	4	3



There are no technological risks, the gas composition at the reactor inlet in both cases is nearly the same.

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Coal Gasification

- Sasol-Lurgi gasifier can use high ash coals (30% ash) with no problems
- 54 t/hr of coal produces 65,000 M^3n/hr of syngas
  - ✓ Adequate volume for 500,000 tpa DRI plant
  - ✓ This technology being implemented at JSPL for 1.6 Mtpa Energiron plant

DRI Production Cost (Including cost of syngas production)

DR Plant	Unit	Unit Cost	HYL DR Module based on Syngas 70% pellets; 30% lump ore	
Metallization	%		≥ 93	
Carbon	%		2.5	
DRI Temperature at EAF	°C		600	
Concept		US$/unit	Specific Consumption	$US/t DRI
Pellets	t	100.0	0.98	98.00
Lump ore	t	80.0	0.42	33.60
Total Syngas	Nm3	0.050	872	43.25
Electricity	kWh	0.05	75	3.75
Oxygen	Nm3	0.05	5	0.25
Water	m3	0.02	1.0	0.02
Other consumables	$US			0.60
Variable Cost	**$US**			**179.47**
Maintenance	$US			3.01
Labour	m-h	3.5	0.17	0.60
G&A	$US			1.00
Fixed Cost	**$US**			**4.61**
Total Operating Cost	**$US**			**184.08**

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Capital Cost Components

- Sasol-Lurgi Fixed Bed Dry Bottom Gasifier
  - ✓ Unit for 500,000 tpa DRI plant
    - Approx. US$60M
- HYL Energiron ZR Plant
  - ✓ 500,000 tpa capacity
    - Approx. US$90M
    - Based on “worldwide turnkey price”; can be significantly lower via Indian supply
- Investment recovery in 3-4 years at current scrap/DRI prices

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Advantages of HYL Energiron Using Syngas

- Recycling of reducing gases through CO_2 removal, to minimize Syngas make-up.
- HYL experience in design and operation of CO_2 absorption units within Direct Reduction environment.
- HYL experience in design and operation of PG Heaters for this application.
- HYL experience in design and operation with different gas composition to prevent potential problems in the PG heater (metal dusting) and in reactor (swelling).
- No major changes or innovations. The reduction section of the HYL plant is unchanged. No technological risks involved
- The gas composition at reactor inlet will be similar to the one at the 4M-ZR at Ternium Hylsa, Monterrey.

Advantages for India

- Natural gas based Micro-Modules can replace small scale DRI production via coal processes
  - ✓ Cleaner alternative
  - ✓ Improved product quality
- HYL Energiron plants using Syngas
  - ✓ Provide optimum use of low grade coals
  - ✓ Cost efficient, quality DRI production