



**ENERGIRON**<sup>HYL</sup>  
THE INNOVATIVE DIRECT REDUCTION TECHNOLOGY

# THE SMART CHOICE



ENERGIRON is the innovative HYL Direct Reduction Technology jointly developed by Tenova and Danieli.



**TENOVA** is a worldwide supplier of advanced technologies, products and engineering services for the iron & steel and mining industries providing innovative integrated solutions. Tenova HYL, the pioneer of modern direct reduction, develops and supplies leading-edge DR technologies leveraging long-standing R&D activities in iron & steel.

**DANIELI** is one of the world's leading firms in the iron and steel industry, and brings its extensive experience and tradition of excellence in engineering and plant making together with R&D experience to form, jointly with Tenova HYL, the ENERGIIRON alliance.





## THE PROCESS

The ENERGIRON Process converts iron ore pellets or lumps into metallic iron with a counter-current flow of very hot (950-1100°C) reducing gases at high pressure (6-8bar). The ZR process configuration exploits the catalytic power of the DRI in the shaft furnace, eliminating the need for a reformer.

The reduction circuit easily accepts any source of reducing gas (H<sub>2</sub> and CO) to produce a highly metallized, high-carbon DRI product. A CO<sub>2</sub> removal system captures CO<sub>2</sub> from the recycle gas, restoring its full reduction potential. Sulfur is removed together with the CO<sub>2</sub> to prevent any sulfur buildup in the circuit, and any remaining tail gas goes to the process gas heater as fuel. The process is easily the most energy-efficient and versatile DR technology on the market.

The ZR Process accepts any reducing gas source – direct natural gas, syngas from a coal gasifier, coke oven gas or any other H<sub>2</sub>/CO source – all with the same flexible process configuration.

PROCESS		
OTHERS	ENERGIRON ZR	ENERGIRON ZR ADVANTAGES
Ambient pressure	High pressure	Lower fines loss, increased flexibility, smaller-size equipment
Reformer required	No reformer	No expensive catalyst, simpler plant configuration
Different scheme for each reducing gas option	Same basic scheme for any reducing gas (NGas, Syngas, COG)	Independent reduction circuit, in-situ reforming, lower energy consumption
X	CO <sub>2</sub> removal system is standard	Environmental benefits, source of cash revenue



## THE PLANTS

ENERGIRON technology provides a compact, highly efficient plant with no technology risk involved, regardless of the energy source. Available plant sizes range from the 200,000 tpy Micro-Module to plants of 2.5 million tpy capacity in a single module. Not just on paper, but proven operations.



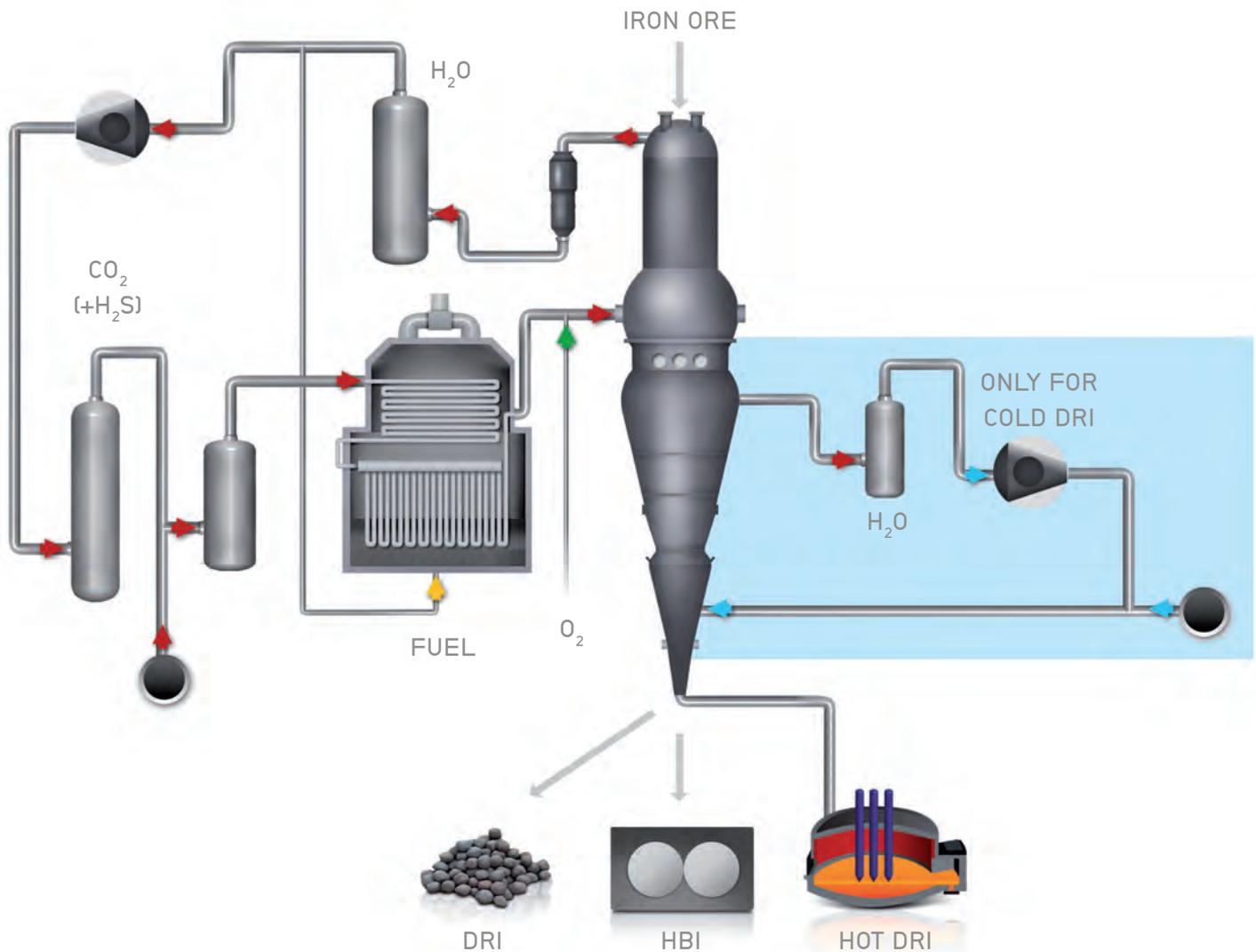
## ENERGIRON: THE INNOVATIVE DR TECHNOLOGY

Tenova HYL and Danieli have formed a strategic alliance to serve the DR plant market.

Under the alliance, the two companies have combined their know-how and technology for the design and construction of gas-based DR plants, offered worldwide under the EN-ERGIRON trademark.

Tenova HYL and Danieli can support customers for any type of project of any size, from a DRP technology package to a full turnkey project.

The characteristic high-carbon DRI (>3%) produced by our technology is unique in the industry: providing ENERGY + IRON for quality steelmaking.



### REDUCING GASES SOURCES

- Natural Gas
- Reformed Gas
- Coal Gasification
- COG
- Others



## THE PRODUCT

Plants using the ENERGIRON technology produce the highest quality DR product – whether in the form of Cold DRI, HBI or Hot DRI for direct feeding to a steel melt shop. The ZR Process enables controlled production of DRI carbon, typically from 1.5 to 4%, in the form of combined carbon ( $Fe_3C$ ), a highly valuable resource for electric furnace steelmaking.

Since the carbon is in combined form, the DRI is more stable than traditional DRI. Independent tests show no re-oxidation in the presence of air and seawater, making it a more

attractive product for shipping to offsite consumers.

For merchant plants, production of HBI is also available. The IMO regards HBI as a safe product for maritime transport.

For plants adjacent to an EAF shop, the HYL HYTEMP® system is the industry's most reliable method for transporting hot DRI directly to the furnace. The combination of high temperature (>600°C) and high carbon content in the DRI delivers significant cost and energy savings in the EAF, with much lower melting times and higher overall productivity.

	PRODUCTS		
	OTHERS	ENERGIRON ZR	ENERGIRON ZR ADVANTAGES
<b>Iron ore feed</b>			
Sulfur limitation	0.001–0.002%	None	Widest range of iron ores
Screening	6mm/3mm	3.2 mm	Higher yield, lower fines loss
Lump ore use	30% mix	up to 100%	Lower metallic charge cost
<b>Products</b>			
DRI/HBI Metallization	Average 92–95%	Controlled 92–95%	Greater product quality choice
DRI carbon	1 - 2.5%	1 – 4% as iron carbide	Maximum EAF productivity, lowest energy cost per tls, greater product stability
Hot DRI	Mechanical system	HYTEMP system	Proven, safe, reliable high-yield technology
Revenue from sale of CO <sub>2</sub>	X	\$\$/ton DRI	Environmental benefits, source of cash revenue

## PNEUMATIC TRANSPORT SYSTEM

An added advantage of the ENERGIRON technology is the ability to incorporate the HYTEMP Pneumatic Transport System. For feeding hot DRI to an EAF, no other system matches the reliability and performance history of the HYTEMP system. The first industrial system started operation in 1998. To date more than 20 million tons of hot DRI have been trans-

ported without a single incident regarding safety and with an availability record of 100 percent. There are now three plants currently feeding hot DRI to melt shops, and several new plants incorporating the HYTEMP system are currently under construction.





## THE ECONOMICS

Capital and operating expenses for ENERGIRON plants are extremely low. For equivalent production capacity, a ZR plant requires barely half the land area needed for other processes. And because the process is pressurized, overall equipment sizes are smaller, for even greater savings.

Operating expenses are low as well, given the flexibility to use lower-cost ores, the inherent low gas and power requirements (2.30–2.38 Gcal/ton and 60–77 kWh/ton), and the best ore-to-product yield of any DR process (1.38 t screened). Maintenance costs are also minimal, and in plants using the HYTEMP® system, there is virtually no maintenance at all, unlike mechanical systems with lower availability.

By transporting and feeding DRI hot to an EAF with the HYTEMP® system, significant savings are obtained in electrical energy requirements. Use of hot, high-carbon DRI results in a saving of 37 kWh/ton of liquid steel per 1% of carbon in the DRI, and another 26 kWh/ton for every 100°C increase in the DRI feed temperature. When using hot high Carbon DRI, the EAF power consumption can be below 370 kWh/ton for an operation based on 100% DRI. This low power consumption is similar to top class operation based on 100% high quality scrap.

ENERGIRON is the only technology that offers an additional revenue source beyond the DRI product. CO<sub>2</sub> capture and sale to off-takers is a lucrative business, providing millions of dollars in annual income to the DR plant operator.



### ECONOMICS

	OTHERS	ENERGIRON ZR	ENERGIRON ZR ADVANTAGES
CAPEX	Large plant area, includes integrated reformer	No reformer	Less land required, more efficient plant design
	Non-pressurized system with off-gas recycling	Pressurized system, smaller-size equipment	Lower fines loss to off-gas, smaller clarifier and settling tanks
OPEX	Requires top-grade DR pellet feed	Can use any pellet, lump or mix, even high sulfur	Lowest possible iron metallics cost per ton of product
	Higher fines loss to process off-gas	Lower velocity, lower fines loss	Higher yield per ton of ore
	Custom reformer catalyst	No reformer, no catalyst	No maintenance cost for replacing damaged catalyst
	CO <sub>2</sub> is recycled to process gas, excess is flared	CO <sub>2</sub> can be captured and sold to off takers	Lucrative additional revenue source



## THE ENVIRONMENT

Without question, ENERGIRON is the cleanest DR technology available. Depending on the configuration, an ENERGIRON plant can remove from 60 to 90% of total CO<sub>2</sub> emissions, which in other technologies are flared or vented to the atmosphere.

An additional advantage of the ENERGIRON plant is the possibility to design the process for a zero make-up water requirement.

This is possible mainly because water is a by-product of the reduction reaction and it is condensed and removed

from the gas stream. As a consequence, adopting a closed-circuit water system, there is no need for fresh make-up water and actually a small stream of water is left available at battery limit. This feature is particularly attractive for locations where the water is expensive or not available at all.

### ENVIRONMENT

- CO<sub>2</sub> removal – allows capture of CO<sub>2</sub> instead of venting or flaring
- Pressurized system – lower fines loss to settling tanks
- High-carbon DRI – lower electrical energy requirement in EAF
- HYTEMP (Hot DRI) – increases EAF productivity, reduces power needs
- Low NOx emissions – no air preheating equipment needed for energy recovery





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