DANIELI

ENERGIRON

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Are we ready for the H2?

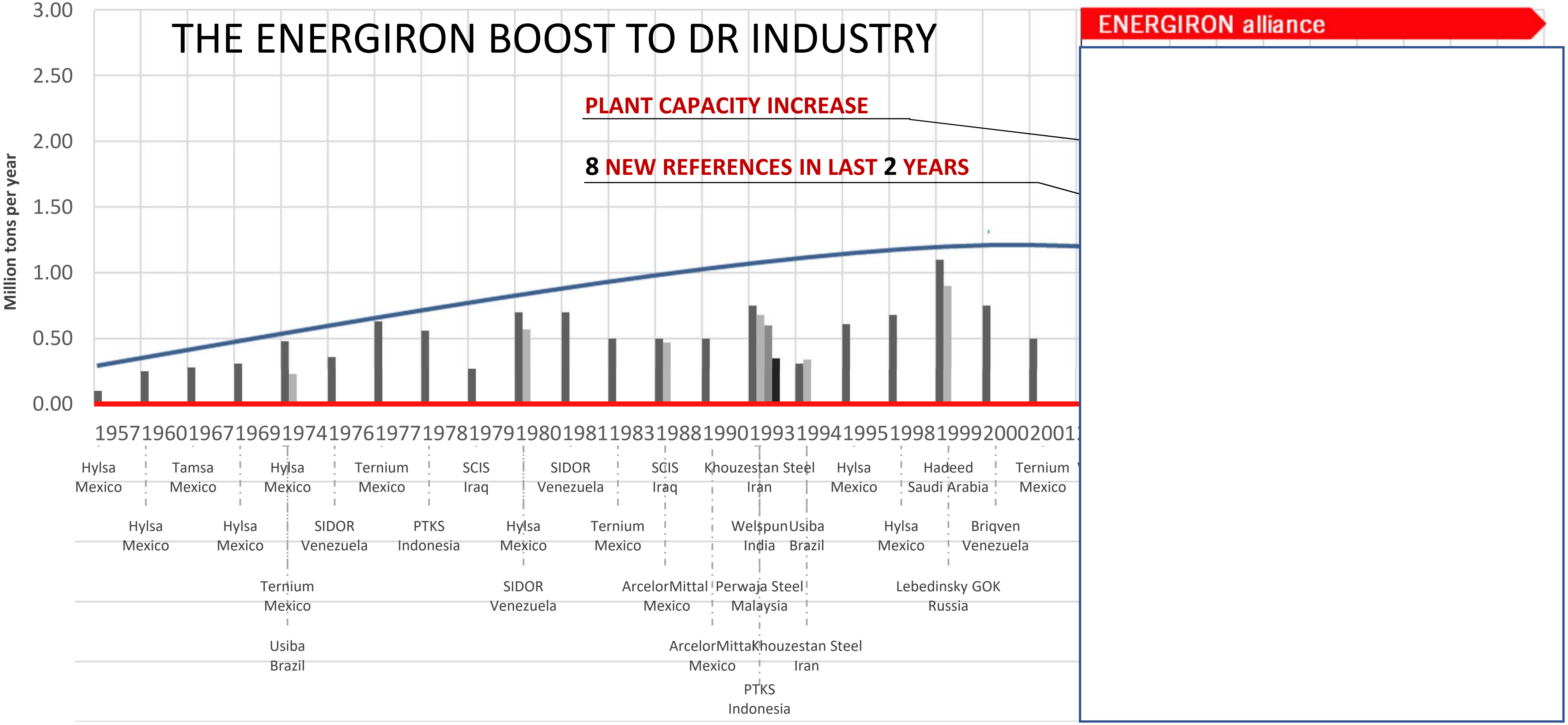
16th Arab Steel Summit
Cairo - Egypt

29-30 October 2023

DANIELI / SINCE 1914
PASSION TO INNOVATE
AND PERFORM
IN THE METALS INDUSTRY

DANIELI TEAM
A CENTURY
OF PARTNERSHIP
EXPERIENCE

ENERGIRON PROCESS


THE ENERGIRON BOOST TO DR INDUSTRY
ENERGIRON alliance
PLANT CAPACITY INCREASE
8 NEW REFERENCES IN LAST 2 YEARS
Million tons per year
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1957 1960 1967 1969 1974 1976 1977 1978 1979 1980 1981 1983 1988 1990 1993 1994 1995 1998 1999 2000 2001
Hylsa Mexico
Hylsa Mexico
Tamsa Mexico
Hylsa Mexico
Hylsa Mexico
Ternium Mexico
Usiba Brazil
SIDOR Venezuela
Ternium Mexico
PTKS Indonesia
SCIS Iraq
Hylsa Mexico
SIDOR Venezuela
SIDOR Venezuela
Ternium Mexico
SCIS Iraq
ArcelorMittal Mexico
ArcelorMittal Mexico
Khouzestan Steel Iran
Welspun India
Perwaja Steel Malaysia
PTKS Indonesia
Usiba Brazil
Khouzestan Steel Iran
Hylsa Mexico
Hylsa Mexico
Hadeed Saudi Arabia
Lebedinsky GOK Russia
Briqven Venezuela
Ternium Mexico

TECHNOLOGY OVERVIEW

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FLEXIBILITY

> Same scheme for any energy source

ENVIRONMENTAL

> lowest NOx emissions: 0,030 kg_{NOX} / t_{DRI}

> Selective removal of iron ore reduction's by-products: H_2O & CO_2

> Use of gas implies that coke/coal is no longer needed as in blast furnace

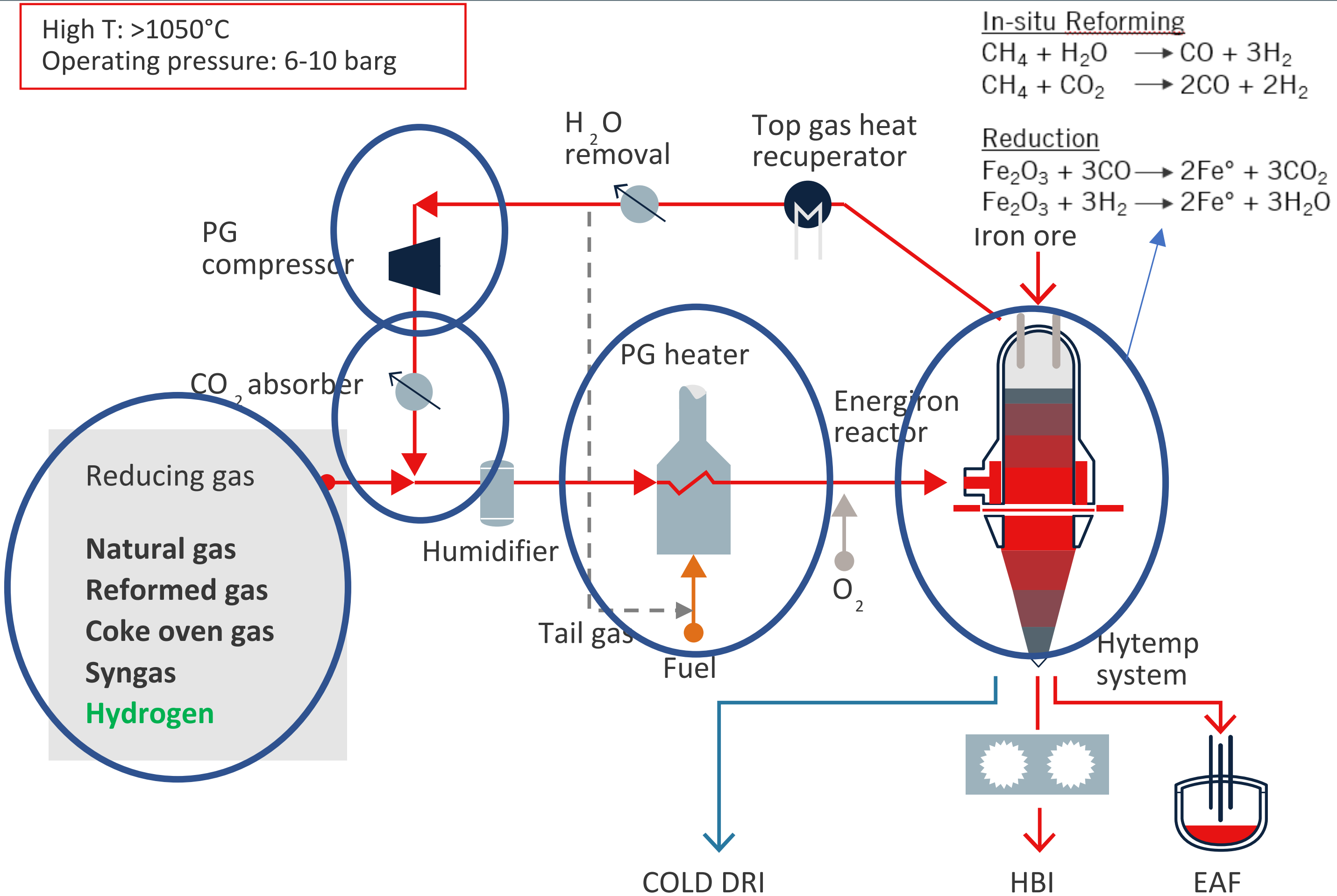
DRI QUALITY

> High-C CDRI, High-C HDRI, High-C Briquettes

> 94-96% Mtz; 1,5%- 4,5% Carbon (as Fe_3C)

OPEX

> Highest overall energy efficiency
< 2,35 Gcal/t; < 80 kWh/t
High yield: <1,4 t_{IOP}/t_{DRI}



OUR HYSTORY WITH H2

OUR HISTORY WITH H2

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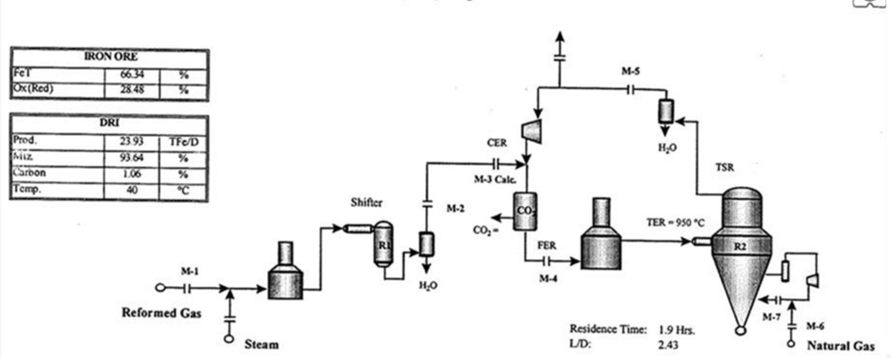
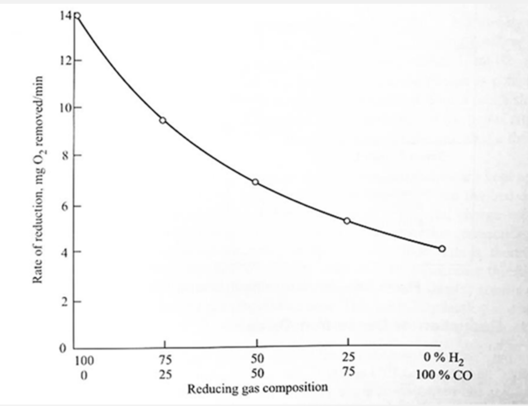
PIONEERING EXPERIENCE

In the **1990's**, was carried out extensive tests at pilot plant with up to **90% H_2**, to define:

- ✓ Process parameters
- ✓ DRI quality
- ✓ Optimization of operating pressure, reactor L/D ratio, etc. for the proper use, gas distribution and design of the scheme for H_2 utilization.

Figure VI.2.1 Material Balance for Condition 10
High Hydrogen





OUR HISTORY WITH H2

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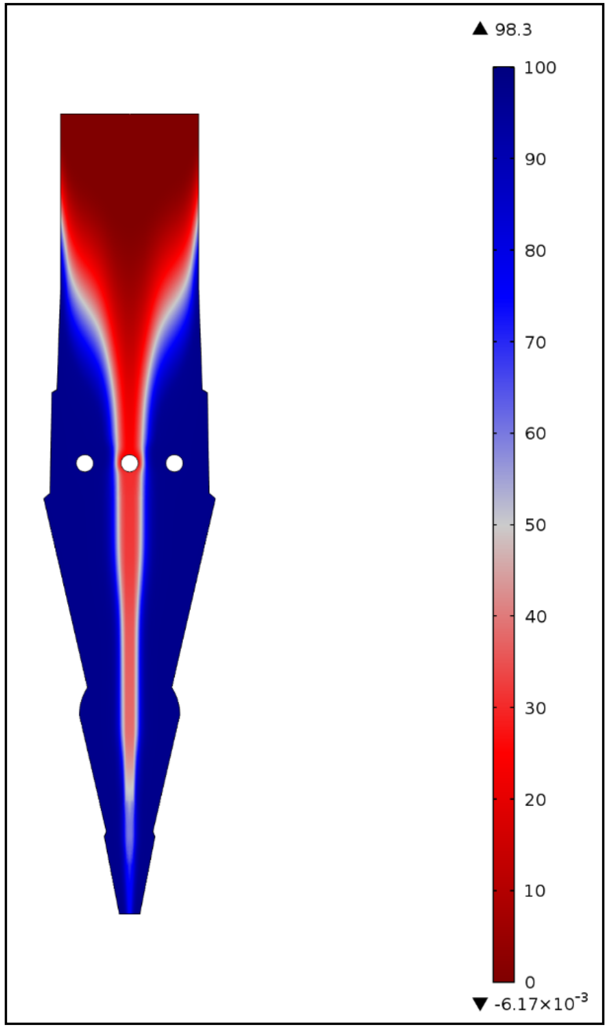
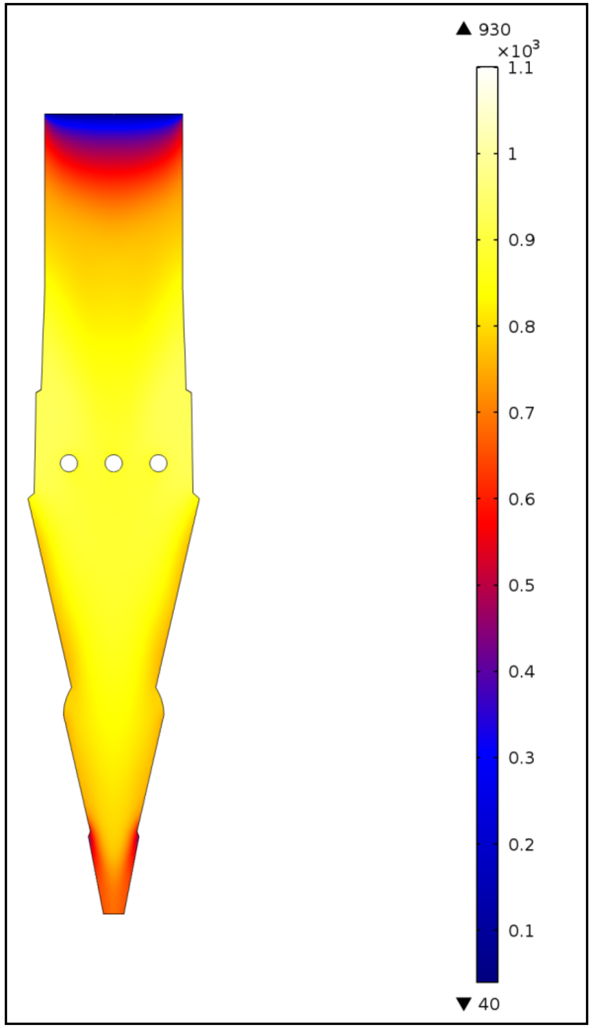
MAXIMUM USE OF H_2:

- Study case: ENERGIRON DRP shaft in hot discharge mode for 250 tph DRI
- Pure H_2 (97% H_2 ; 1% H_2O ; 2% N_2) as PG

RESULTS:

- 94% metallization
- $T_{discharge}$ ~700°C





NG TRANSITION UP TO 100% H_2

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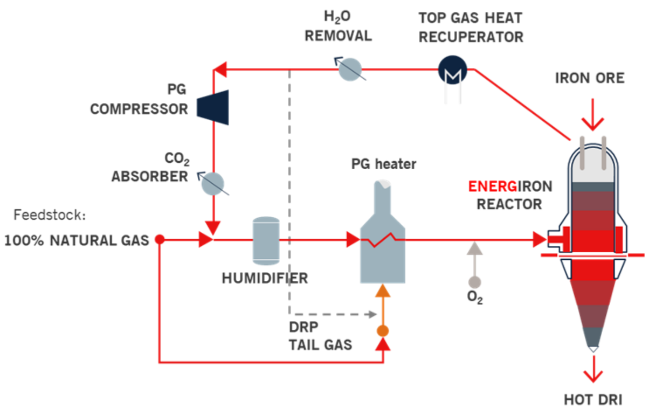
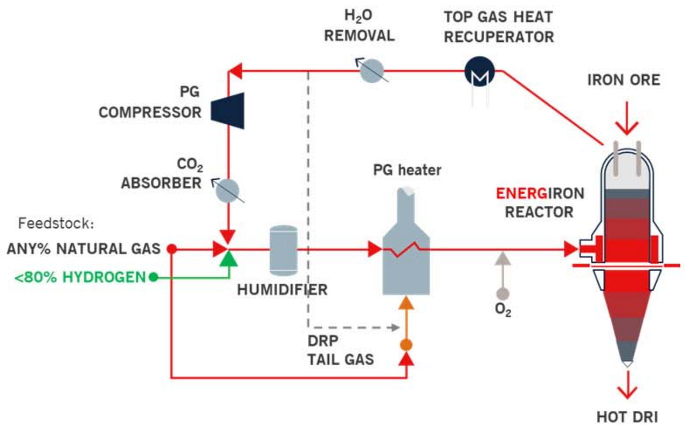
SAME SCHEME FOR PRESENT, NEAR AND FAR FUTURE

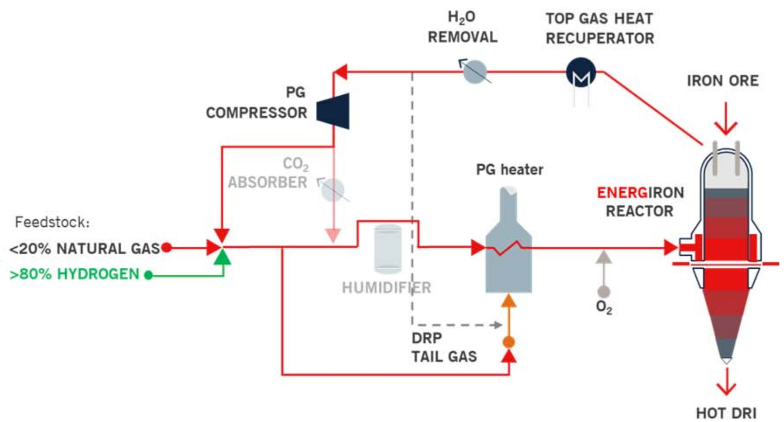
TODAY → **TOMORROW (BY 2030)** → **FUTURE (BY 2050)**



100% Natural Gas



any % Natural Gas
<80% % Hydrogen



Up to 100% Hydrogen

NG TRANSITION UP TO 100% H2

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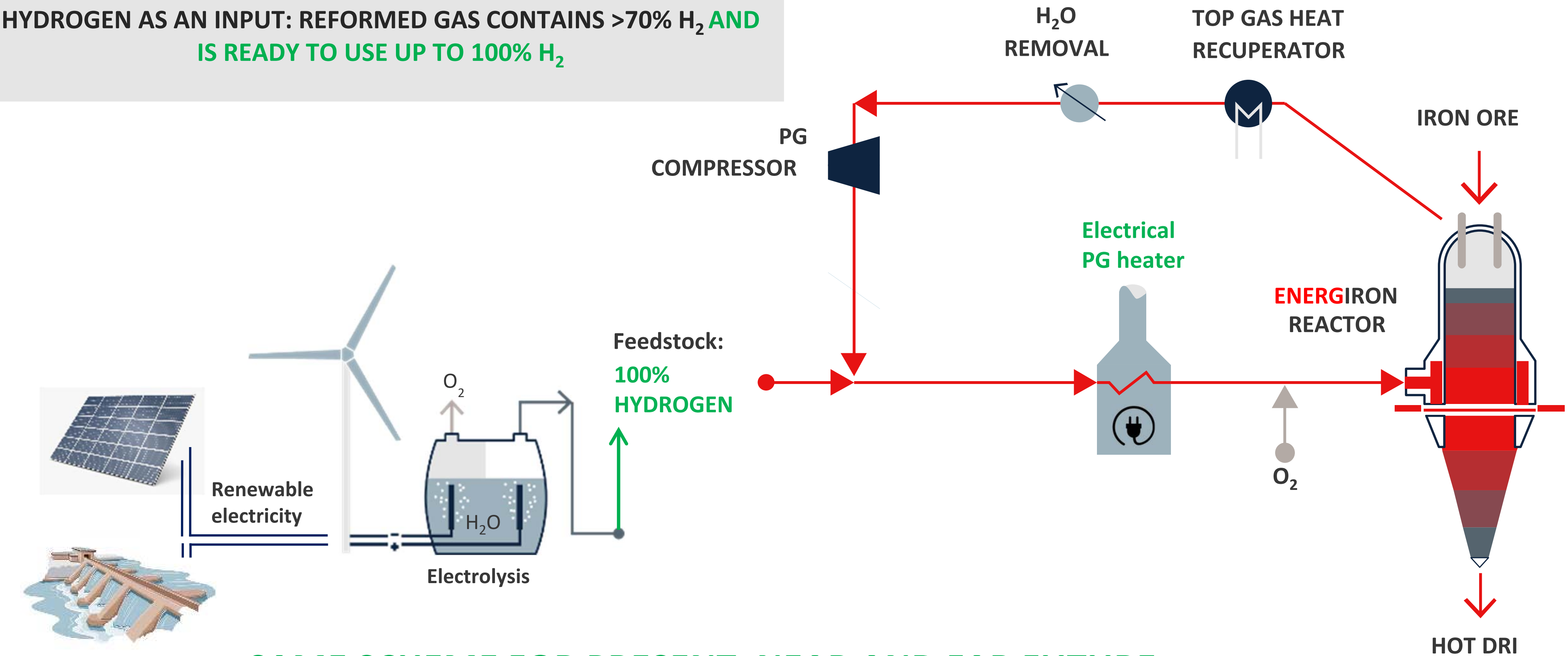
ENERGIRON PLANTS ALREADY USE HIGH CONCENTRATIONS OF HYDROGEN AS AN INPUT: REFORMED GAS CONTAINS >70% H_2 AND IS READY TO USE UP TO 100% H_2



SAME SCHEME FOR PRESENT, NEAR AND FAR FUTURE

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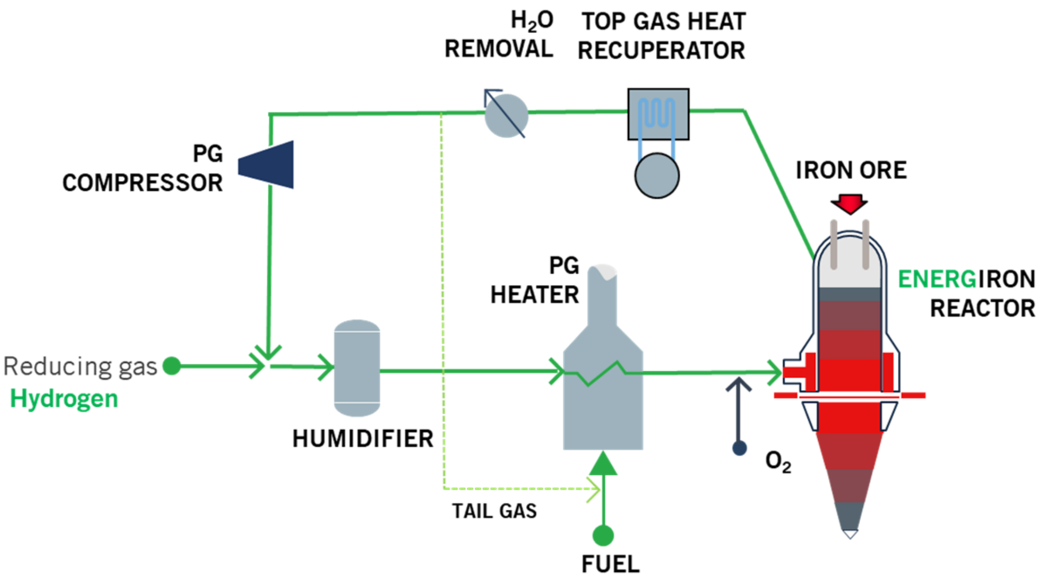
ECONOMICS OF H2

ECONOMICS OF H2

Example for 1 MTY



		%H2	
		100%*	80%*
Carbon content in DRI		0%	0,5%
Yield	t_{IOP}/t_{HBI}	1,44	1,44
H2	Nm3/t	774	637
(H2	Gcal/t)	1,98	1,631
Nat Gas	Nm^3/t	0	44,72
(Nat gas	Gcal/t)	0	0,398
Oxygen	Nm^3/t	0	10
El. Energy	kWh/t	56	68
water	m^3/t	1,4	1,4
Nitrogen	Nm^3/t	22	22
H2	Nm^3/h	**99254**	**81760**
Nat Gas	Nm^3/h	**0**	**5773**

*= percentage its referring to an energy requirement basis and considering the heater fed by hydrogen

…looking the capex, what we need?

1 Ton of Green Iron require ~ 3,5 MWh for hydrogen (~60 kilograms H_2 @55 kWh/kg via water electrolysis)

1 MTY means 125 ton/hr → means ~ 412 MW installed power → 370 M€ (alkaline, 900 €/kW)

Looking to produce the electrical power by renewable energy we have:

- 60 wind turbines (7 MW/each) → 495 M€ (1,2 M€/MW installed)

Or

- 1.375.000 m2 of solar panels (means 190 soccer camp) → 412 M€ (1€/w installed)

Carbon Tax:

Since 2020 the EU ETS carbon prices have undergone a notable increase.
https://tradingeconomics.com/commodity/carbon

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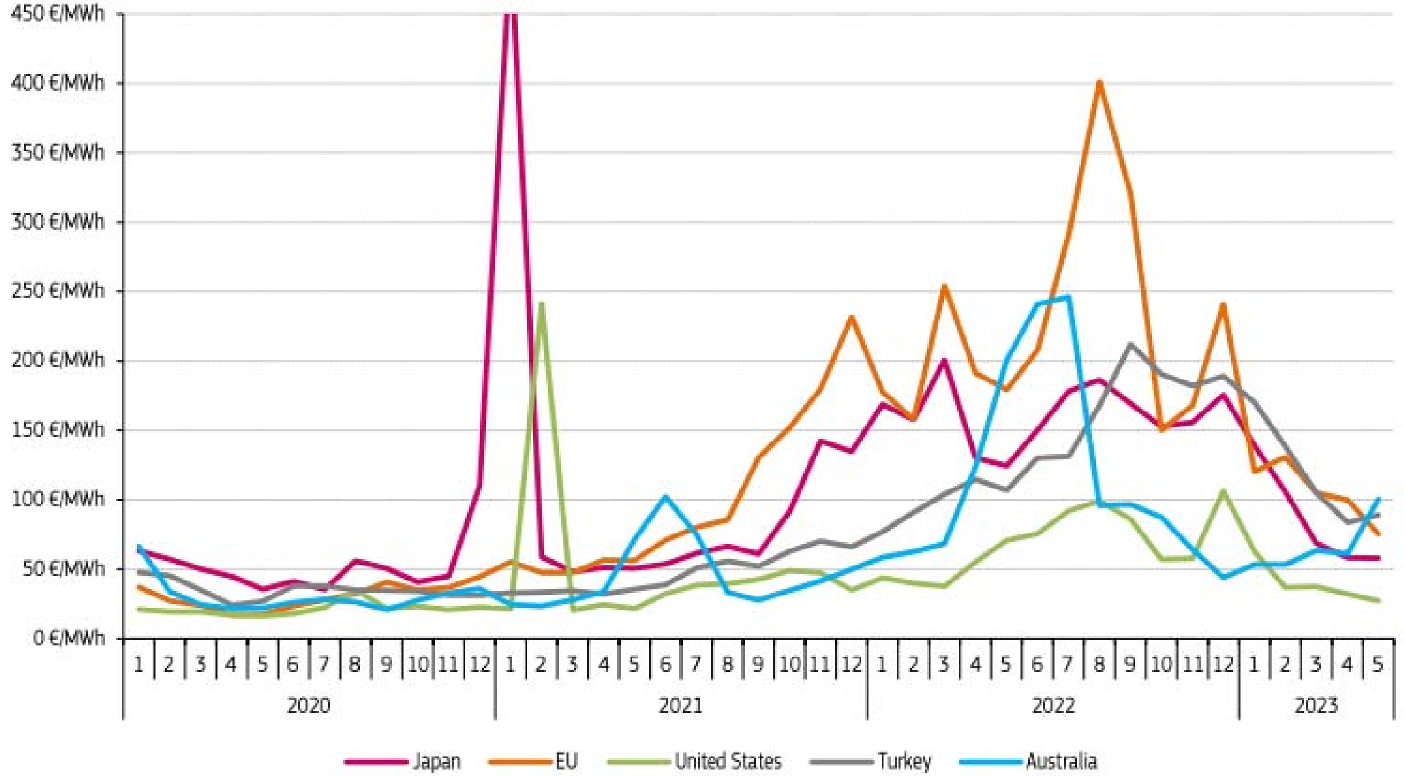
Cost of eletrical power:

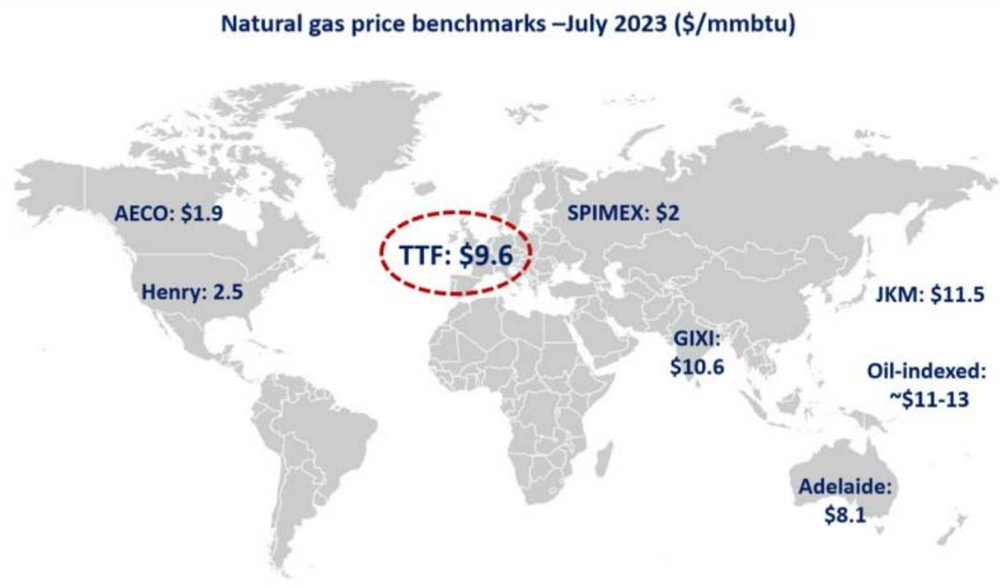
https://energy.ec.europa.eu/system/files/2023-10/New%20Quarterly%20Report%20on%20European%20Electricity%20markets%20Q1%202023.pdf

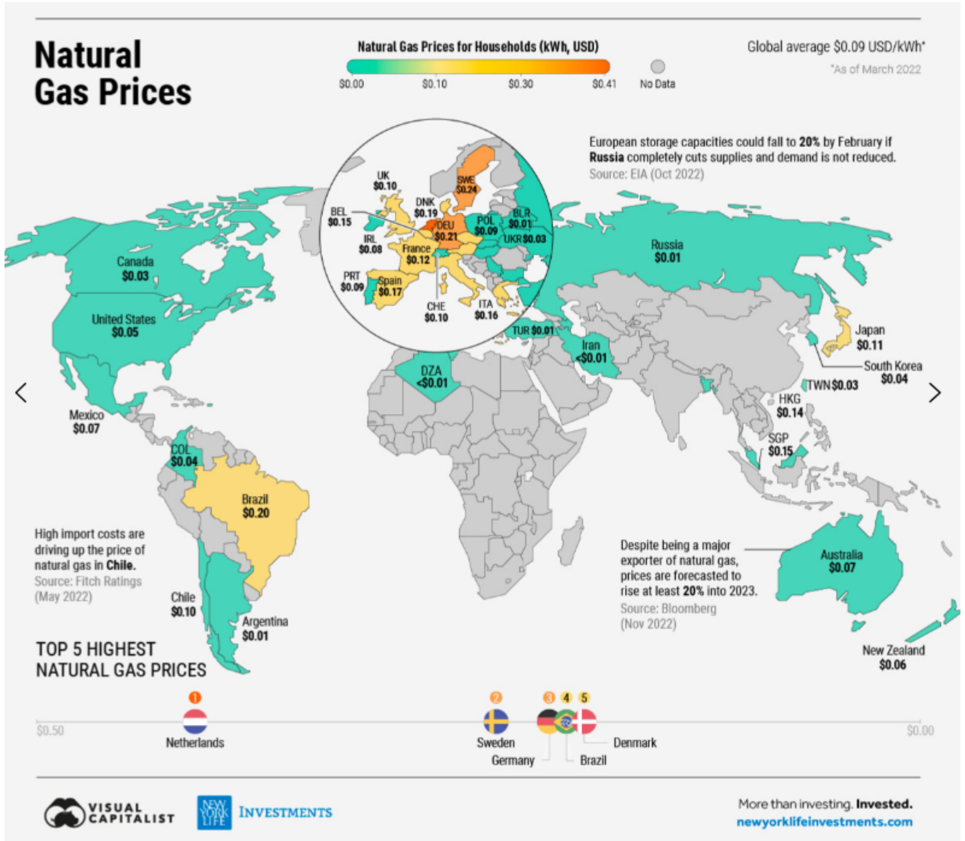


Source: European Power Benchmark, JPEX (Japan), AEMO (Australia), Energy Exchange Istanbul (Turkey) and the average of selected PJM West, ERCOT, MISO Illinois and CAISO regional wholesale hubs in the United States

Cost of natural gas:

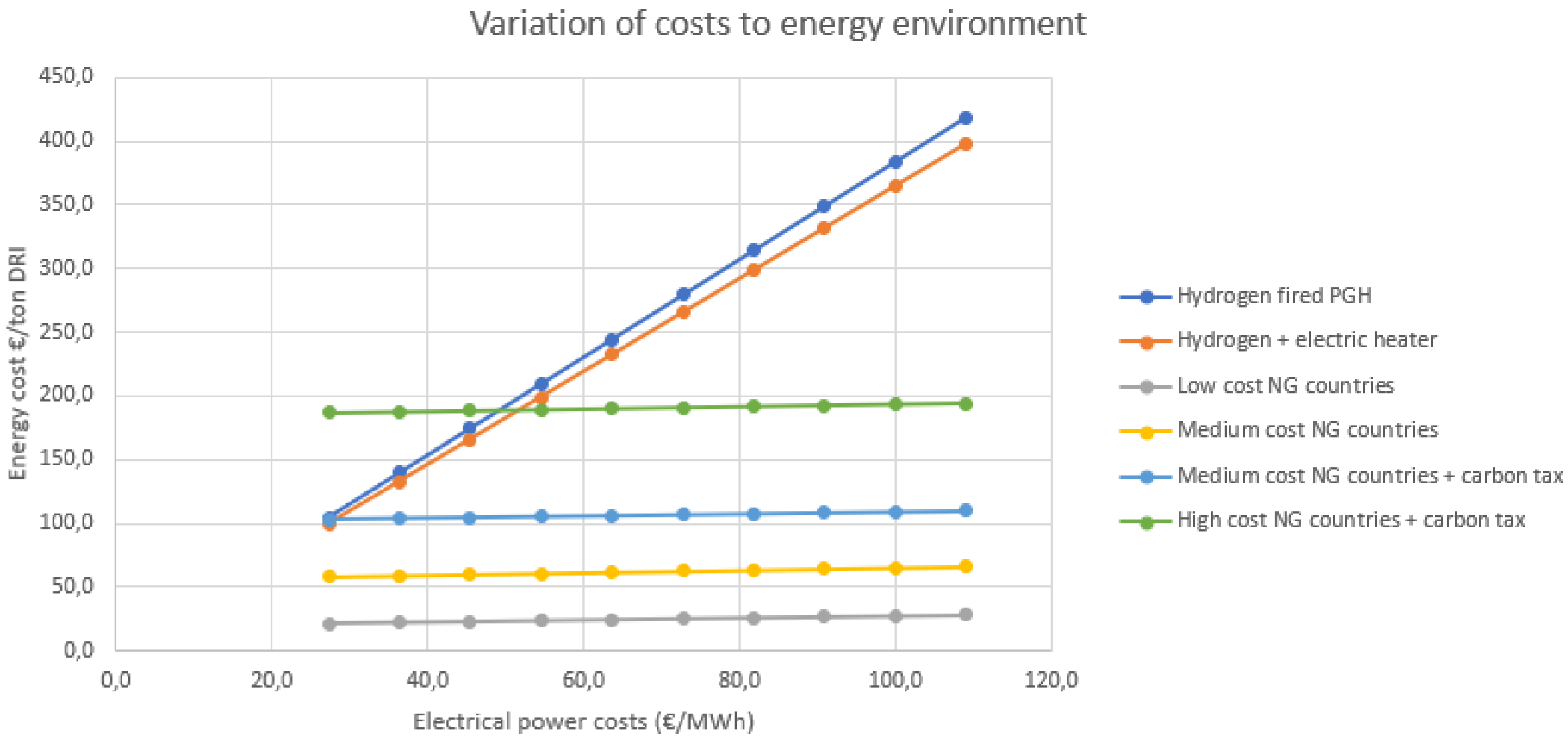
https://advisor.visualcapitalist.com/global-energy-prices-by-country/

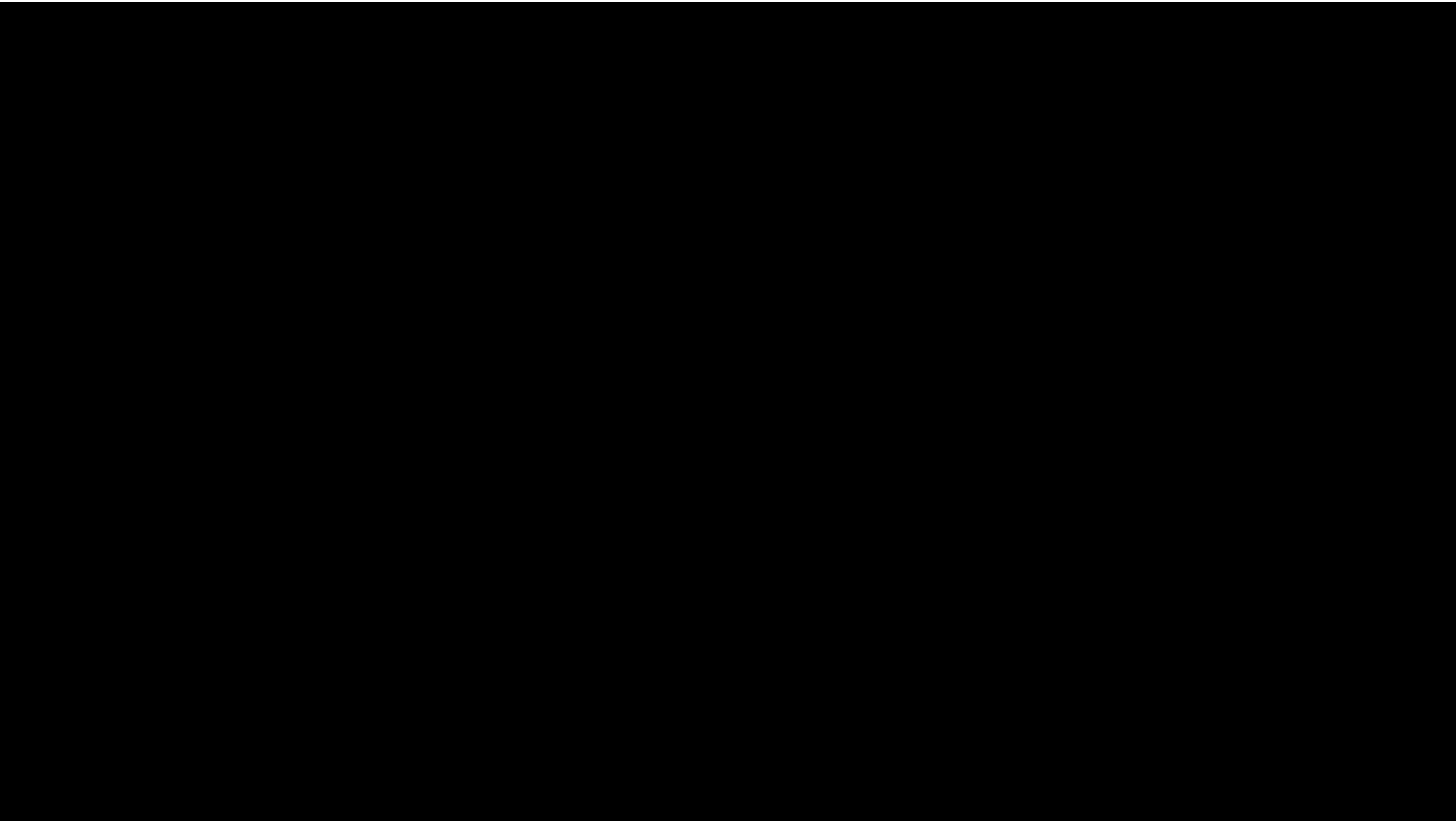




https://globallnghub.com/global-natural-gas-price-benchmarks-july-2023.html

Let introduce also other factors





CONCLUSION

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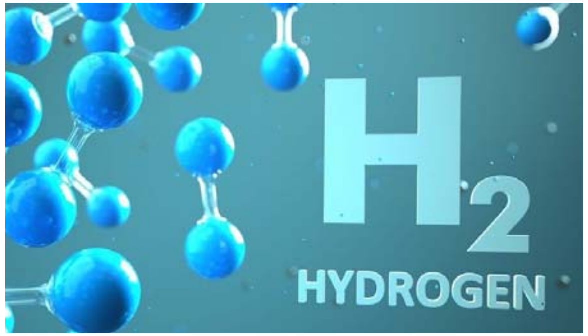
DRI TECHNOLOGY BY TENOVA AND DANIELI



FLEXIBILITY

> Same scheme for ANY energy source

> Already with HIGH % of H2 in the process gas

> Without any change today can absorb up to 80% of H2 from external source

> Same scheme is ready for TOMORROW in case of 100% H2

OPPORTIUNITY FOR SOME AREAS

> Is a good reduction agent

> Can play a rule in the decarbonization

> In some condition can be compentitive solution

Yes, we are ready for the H2!

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