# The influence of green hydrogen on the steel industry

A geopolitical analysis

Overview

1. Motivation and Research Question
2. Iron and Steel making
3. Today's iron and steel value chain
4. Green Hydrogen potential to decarbonize
5. The problem
6. The dilemma

Motivation

- The Steel Industry is integral for countries industrial advancements

- Steel Industry emits 7% of global CO_2 emissions, and will harvest 50% of remaining CO_2 budget if it continues its business as usual

- 90% of steel production is in countries with net-zero pledges

- With the help of renewable electricity and Green Hydrogen, steel industries' emissions can be abated by about 95%
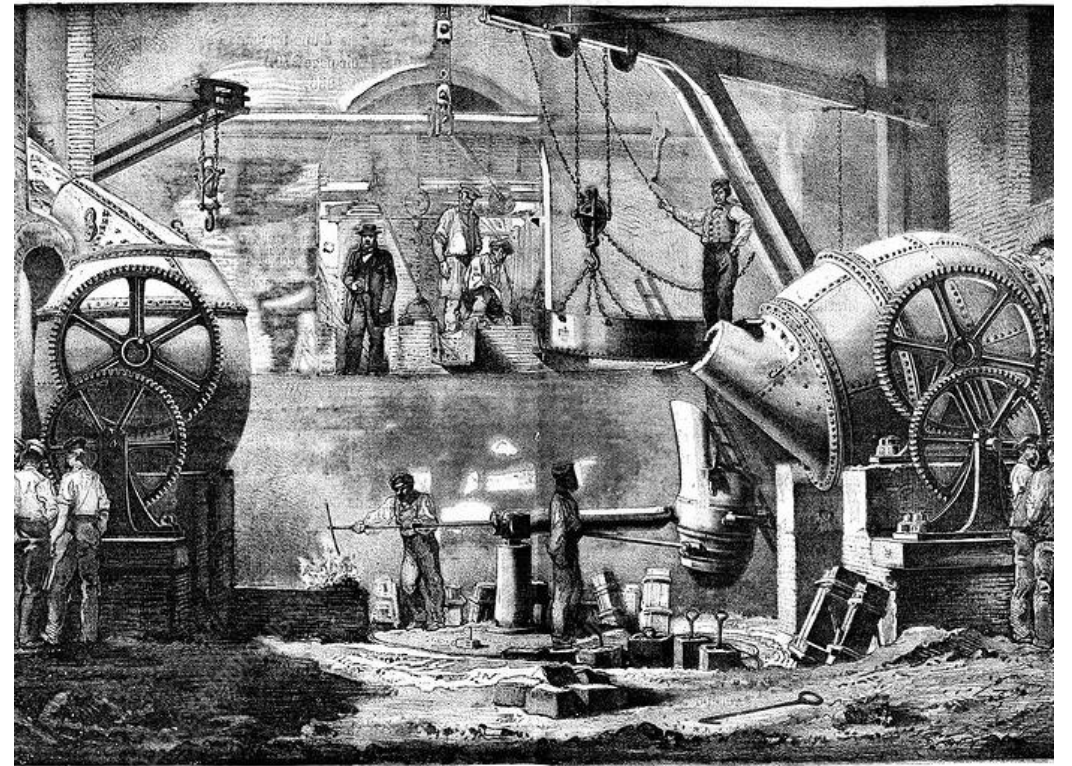
Green hydrogen's impact

- Green hydrogen is produced by splitting water (H_2O) into hydrogen (H_2) and oxygen (0) with the help of renewable electricity

- If you release hydrogen with oxygen (Air) it will combust and release high energy by only having water vapor as a by-product

- **Low energy density per volume** (Hydrogen = 8 MJ/L; Gasoline = 32MJ/L)

- but **high per kg** (Coal = 24 MJ/kg; Gasoline 46 MJ/kg; Hydrogen = 142 MJ/kg)
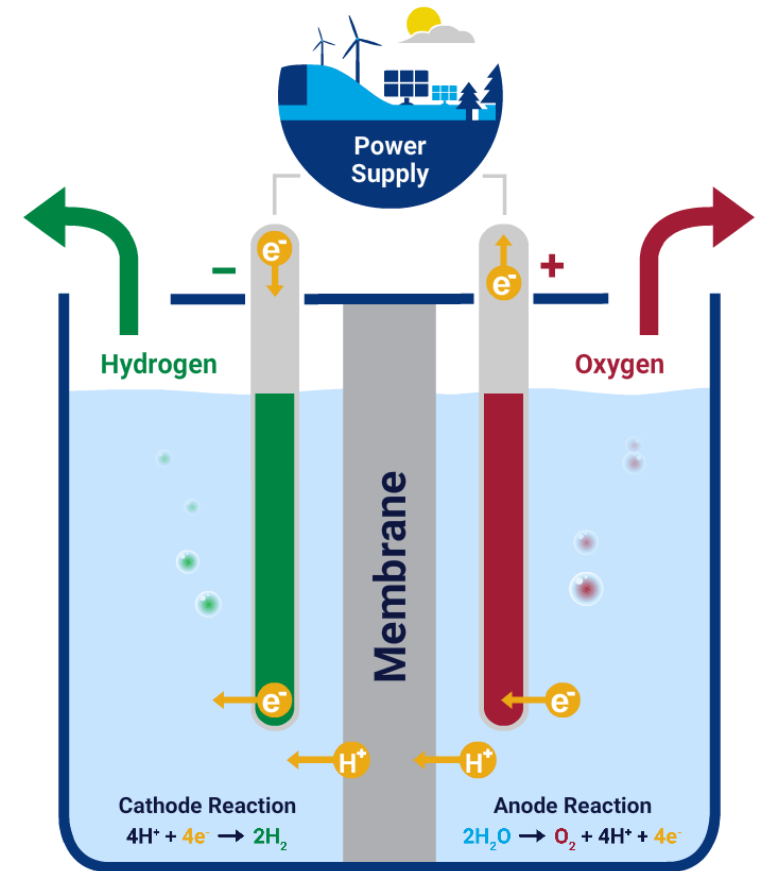
# Hydrogen Storage and Transportation

- Hydrogen can be compressed and stored in a gaseous form under high pressures. This requires storage tanks to have pressures of 350-700 bar

- The first 10% are the most energy intensive
  - 700 bar = 15% of LHV*
  - 350 bar = 12% of LHV
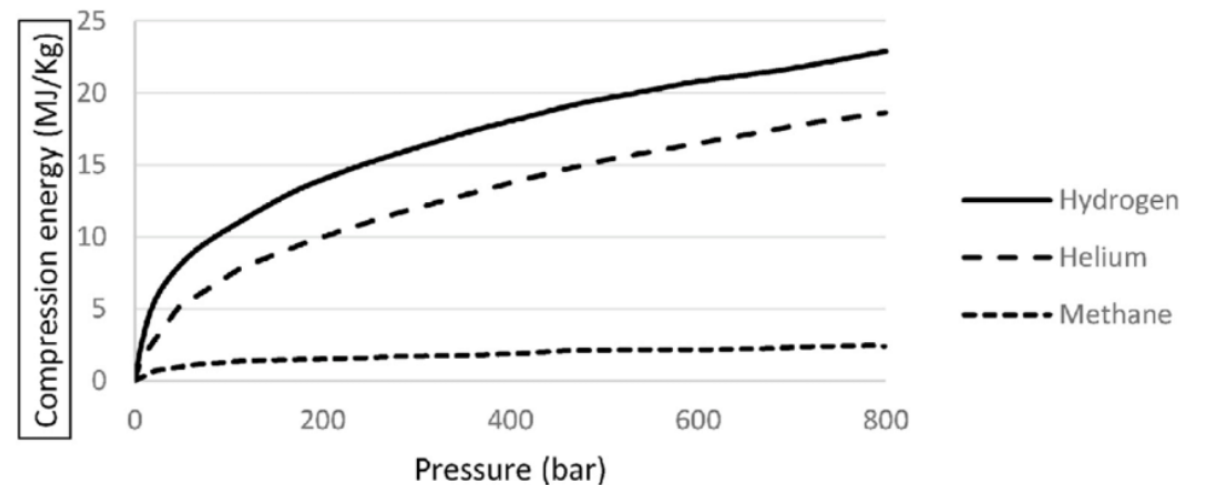
LHV = Lower Heating Value == amount of heat released by combustion

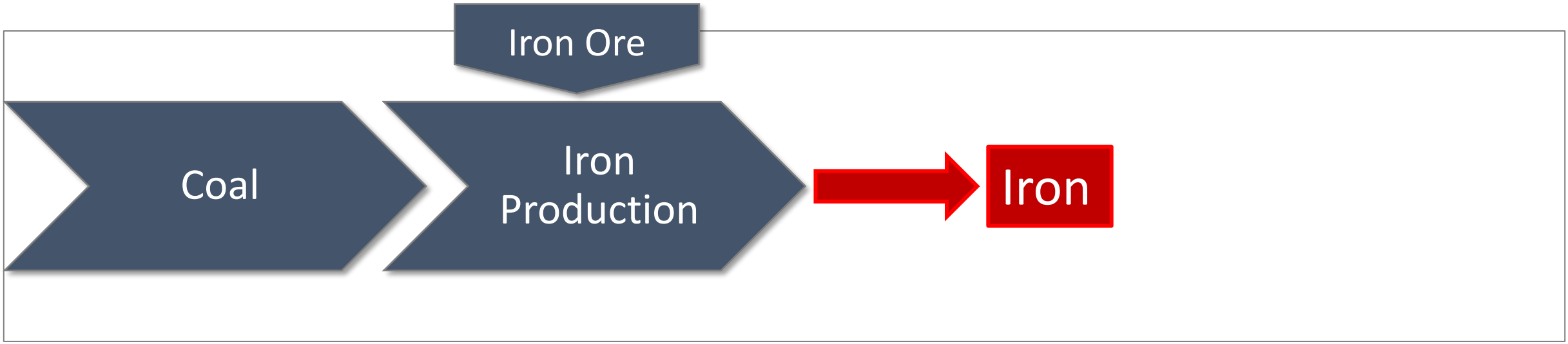# Which countries will take part in the future green steel value chain?

Steel Value Chain
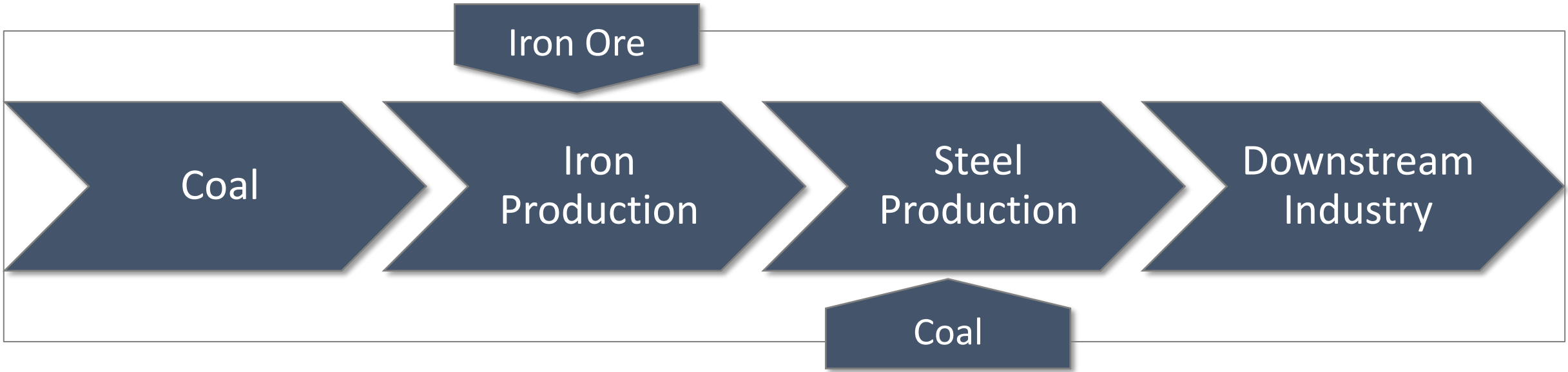
Iron Production

Process	Techno.	Fuel	Energy
Iron Making	BF	Coal	70%
	DRI	Gas	

Iron Ore

Coal ▶ Iron Production ➡ **Iron**

Quality of the iron ore is crucial

Most energy intensive

Blast Furnace (BF) vs. Direct Reduced Iron (DRI)

Steel Production

Process	Techno.	Fuel	Energy
Iron Making	BF	Coal	70 %
	DRI	Gas	
Steel Making	BOF	Coal	30%
	EAF	Elec.	

Scrap

Iron → Steel Production → Downstream Industry

Coal/Elect.
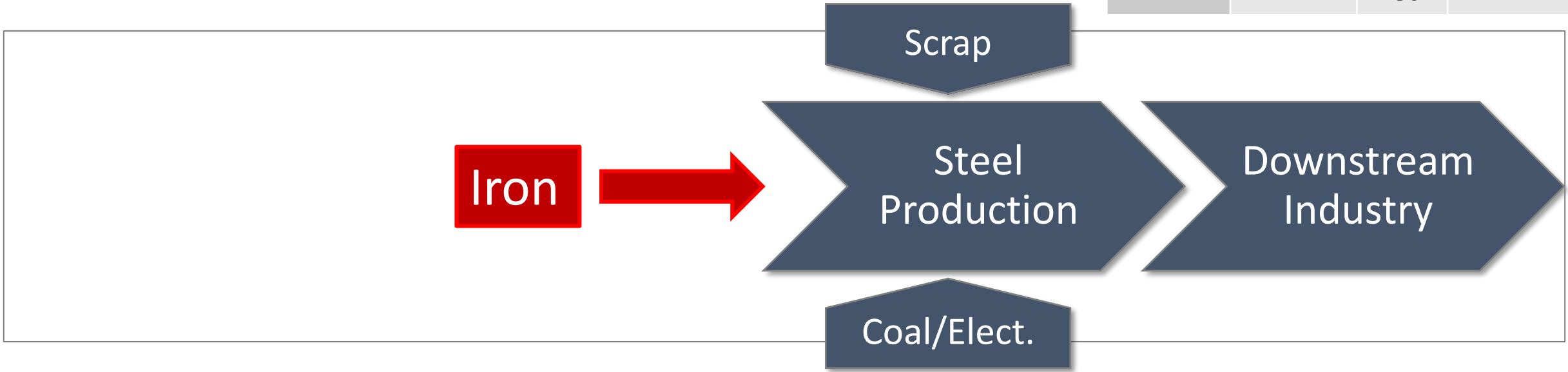
Iron vs Scrap

Most know-how intensive

Basic Oxygen Furnace (BOF) vs Electric Arc Furnace (EAF)

Primary Route

Process	Techno.	Fuel	Energy
Iron Making	BF	Coal	70 %
	DRI	Gas	
Steel Making	BOF	Coal	30%
	EAF	Elec.	

Iron Ore

Coal → Iron Production → Steel Production → Downstream Industry

Coal/Elect.
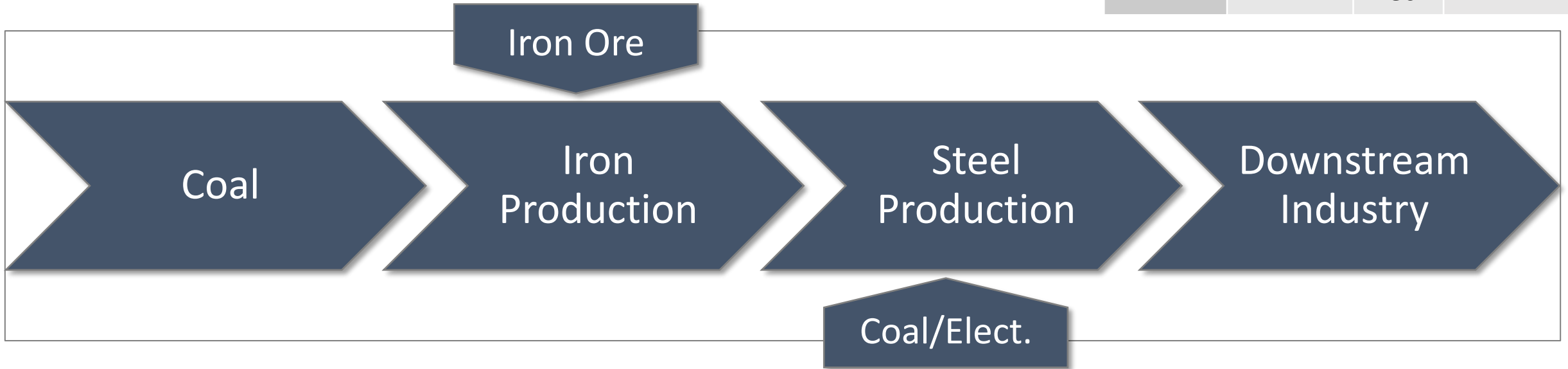
BF-BOF 70% of global steel and 90% of primary route

DRI - EAF

"Virgin steel"

Secondary Route

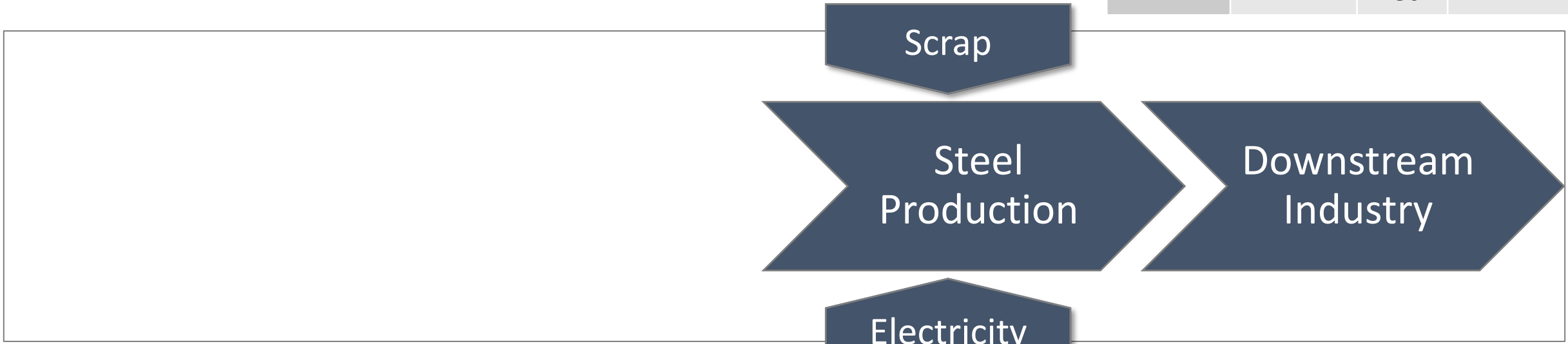| Process	Techno.	Fuel	Energy
Iron Making	BF	Coal	70 %
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Steel Making	BOF	Coal	30%
	EAF	Elec.	

Scrap

Steel Production

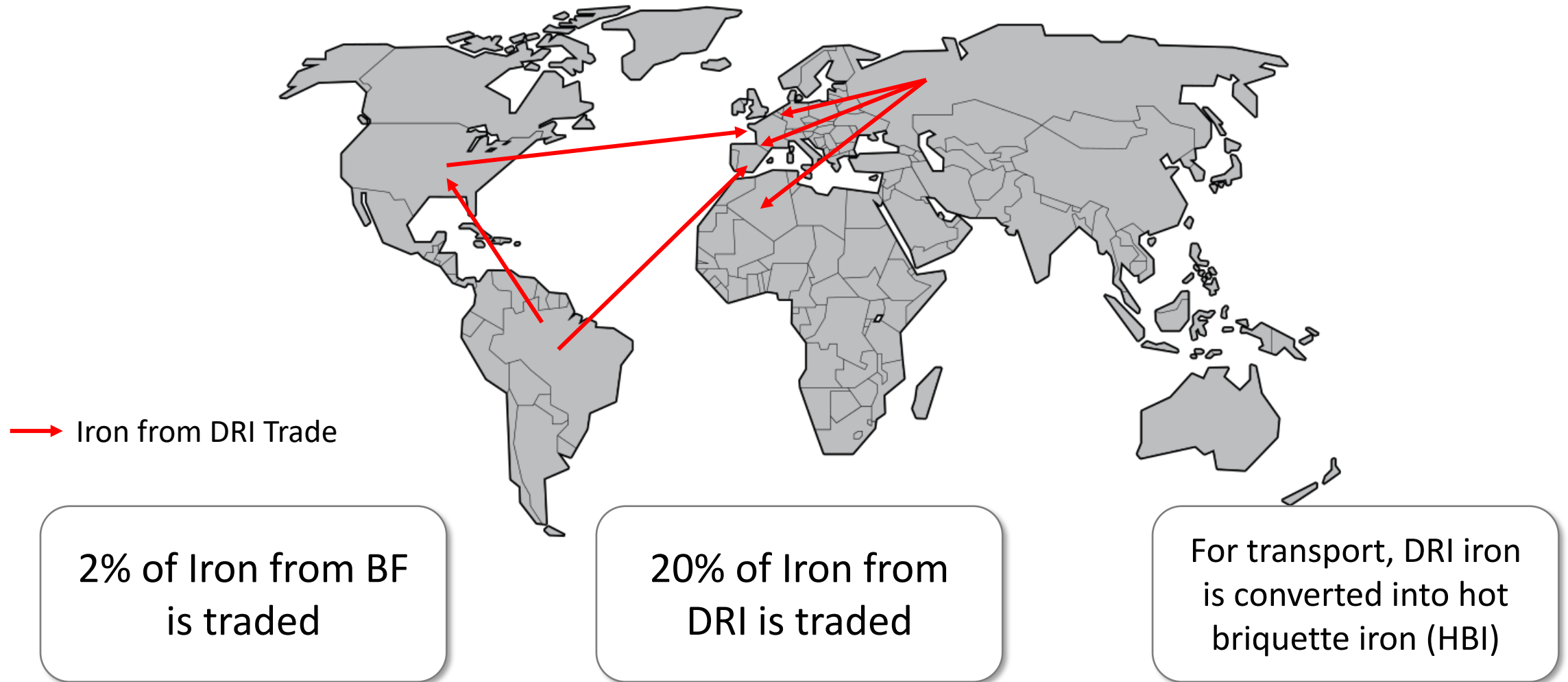Downstream Industry

Electricity

Scrap-EAF 24% of global steelmaking

Low-quality steel

No sufficient scrap supply

Iron Ore Trade

Iron Ore Trade

Scattered across the globe

Three big exporting nations

Difference in quality

Iron Trade

Iron from DRI Trade

2% of Iron from BF is traded

20% of Iron from DRI is traded

For transport, DRI iron is converted into hot briquette iron (HBI)

Steel Trade

Crude Steel Trade

Sensitive to economic dev.

Regional character

Low margin
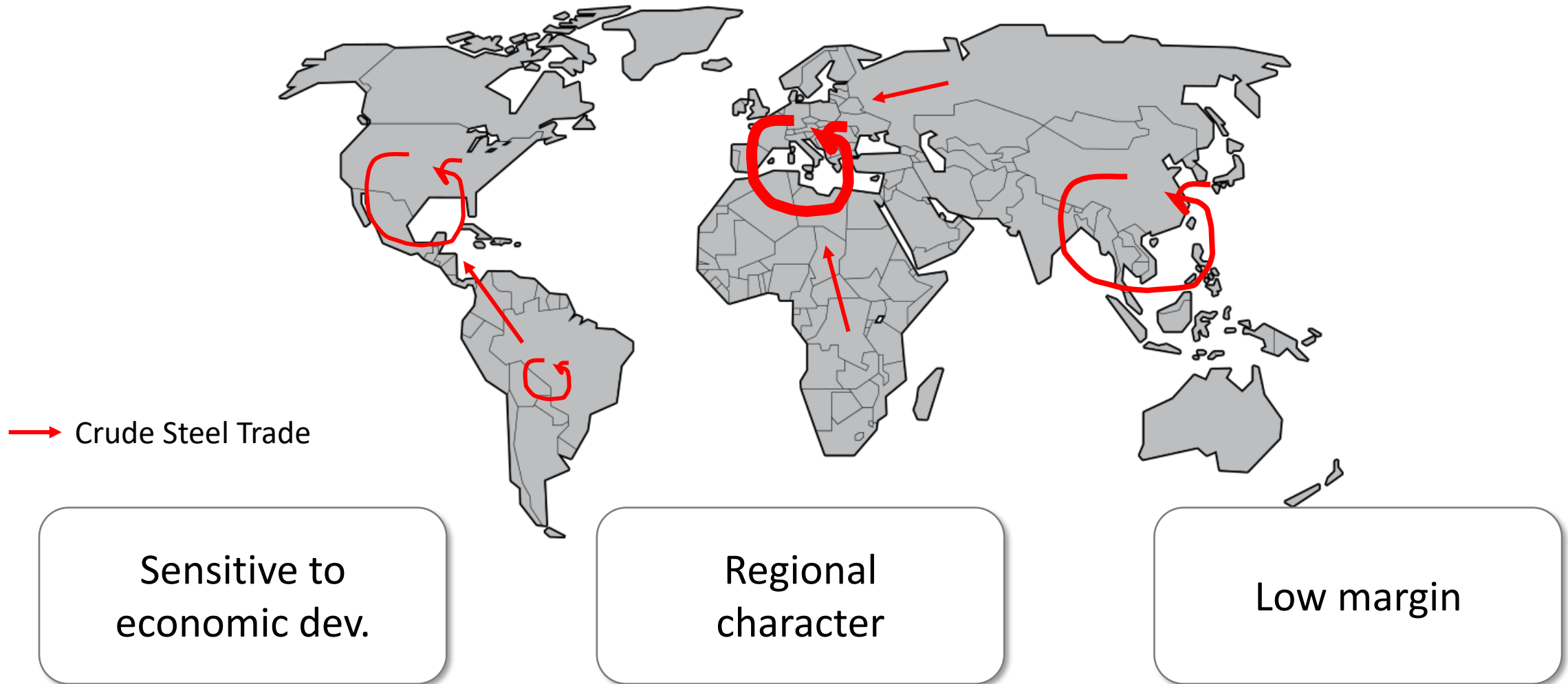
Something needs to change!

Process	Techno.	Fuel	Energy
Iron Making	BF	Coal	70 %
	DRI	Gas	
Steel Making	BOF	Coal	30%
	EAF	Elec.	
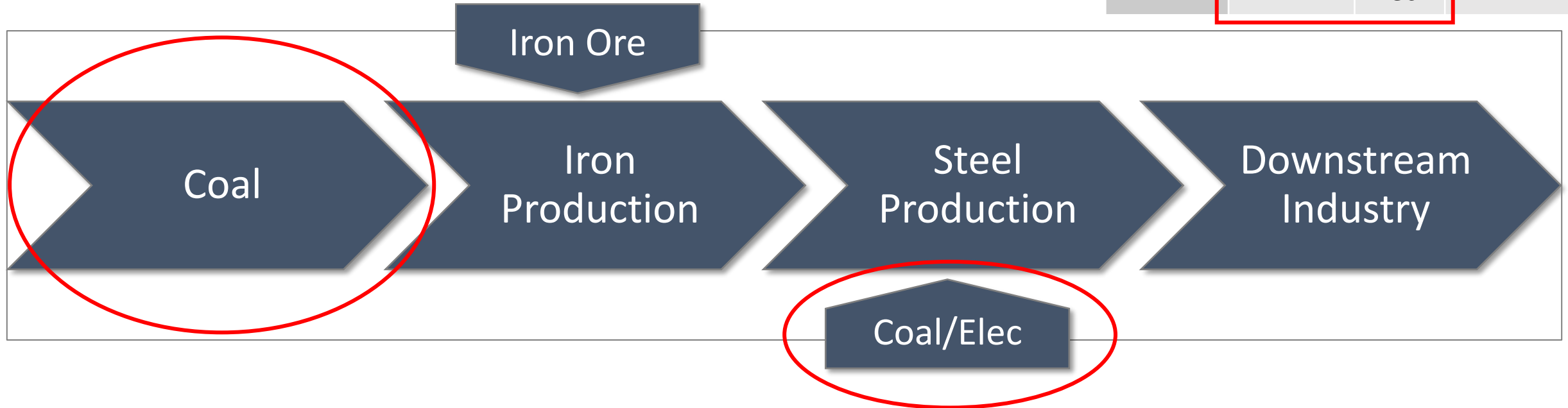
Green Steel Value Chain

Process	Techno.	Fuel	Energy
Iron Making	H-DRI	H2	70%
Steel Making	EAF	Elec.	30%

Water

Iron Ore

Hydrogen Production → Iron Production → Steel Production → Downstream Industry

Ren. Elect.

Ren. Elect.
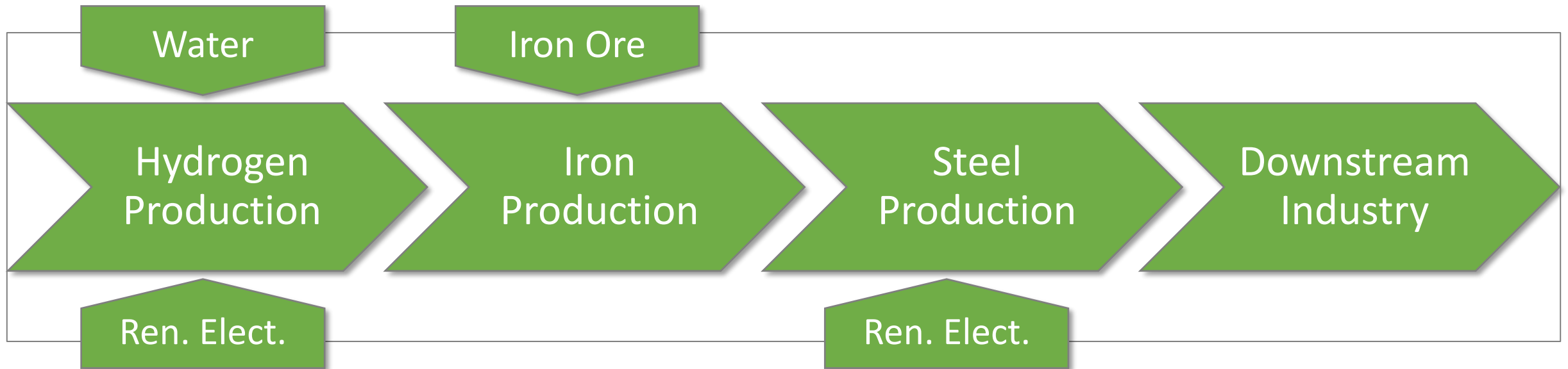
What are the main hurdles for take-off?

+ Water

+ Iron Ore

Water

Iron Ore

Hydrogen Production → Iron Production → Steel Production → Downstream Industry

Ren. Elect.

Ren. Elect.
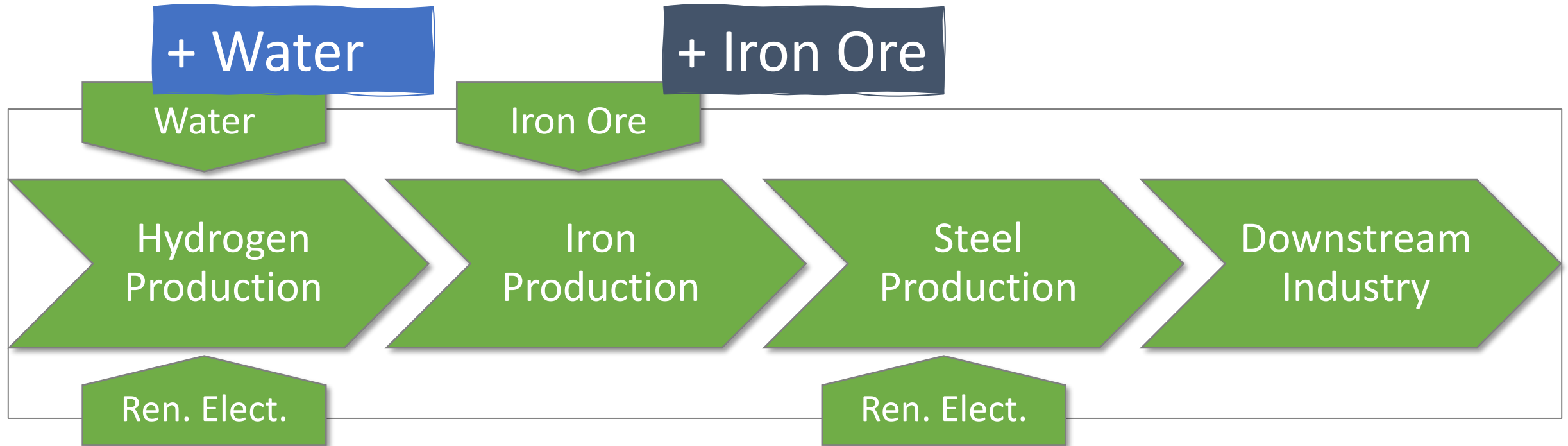
Supply of cheap Hydrogen and Renewables!

PHOTOVOLTAIC POWER POTENTIAL

WORLD BANK GROUP ESMAP SOLARGIS

70.9
42.7 **23**
31.5
78.8
105.2
803.8
89.4
69.7
33.3

Country's steel production (in mio ton):
China (803.8
Japan (105.2)
India (89.4)
USA (78.8)
Russia (70.9)
South Korea (69.7)
Germany (42.7)
Brazil (33.3)
Turkey (31.5)
Ukraine (23.0)
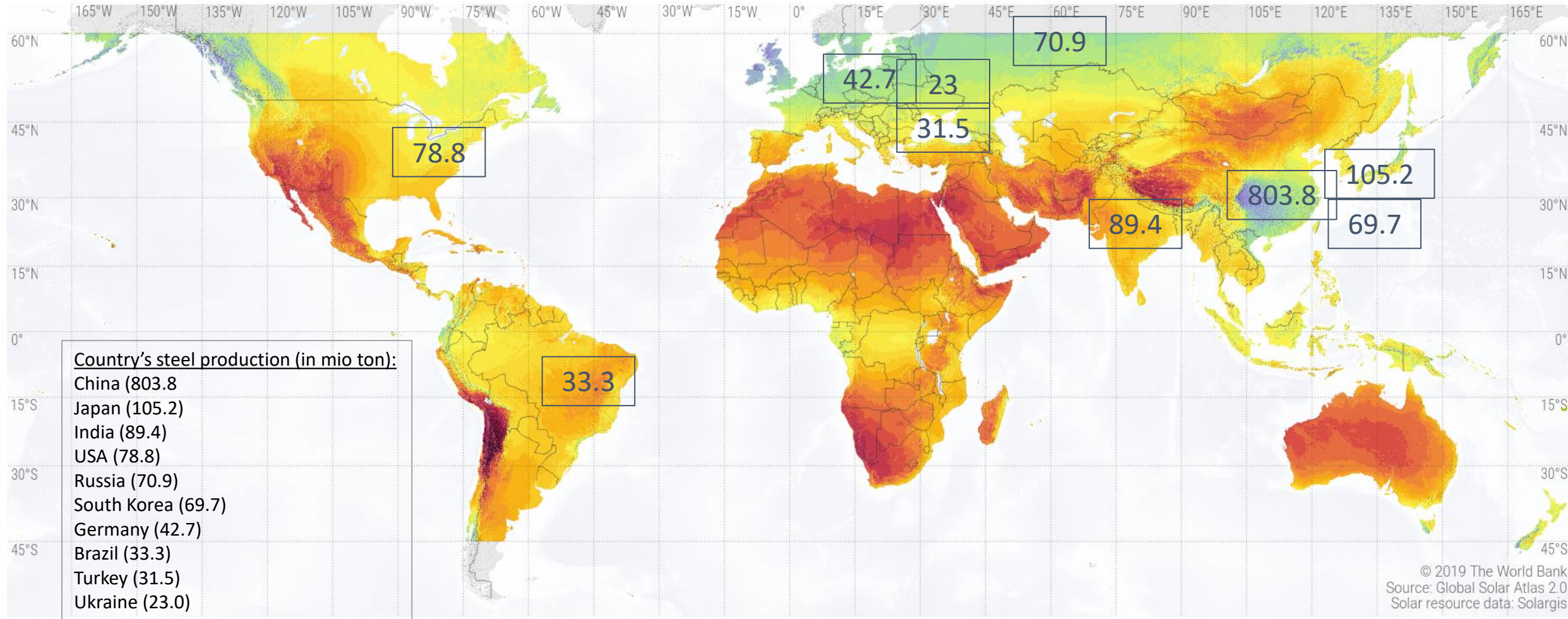
© 2019 The World Bank
Source: Global Solar Atlas 2.0
Solar resource data: Solargis

Long-term average of photovolaic power potential (PVOUT)

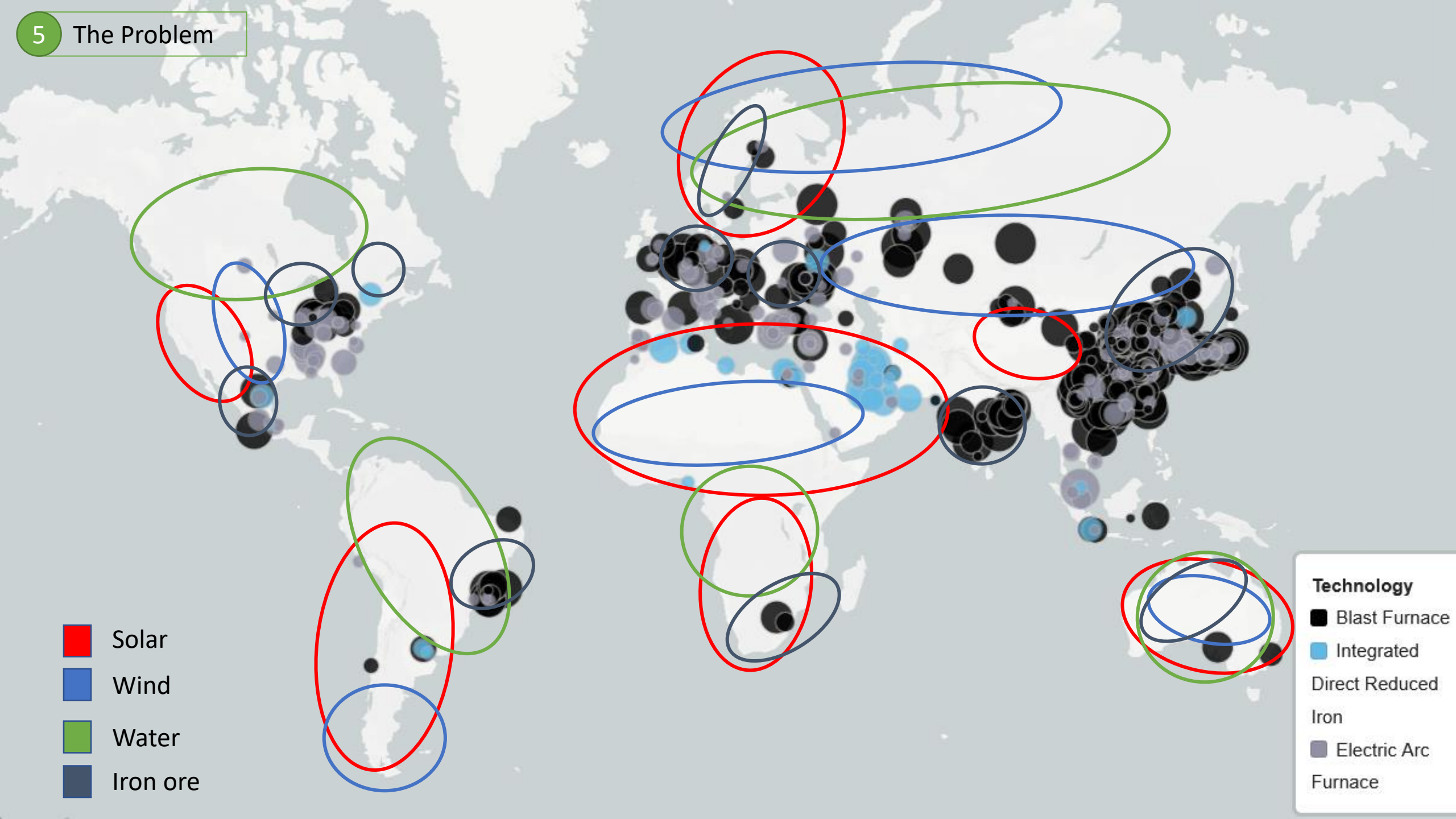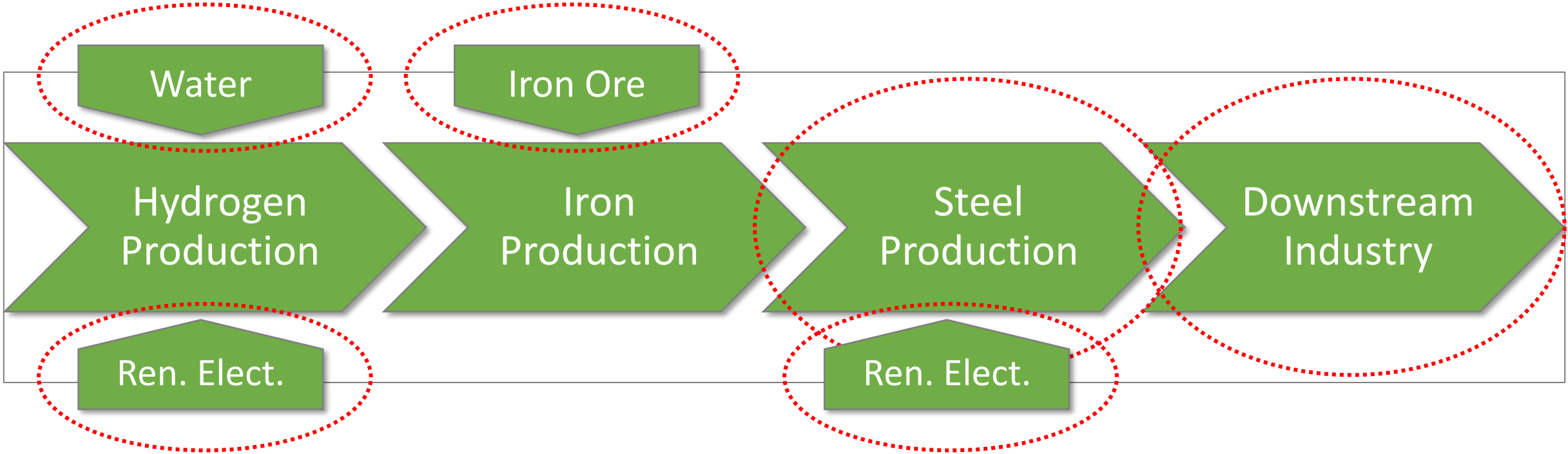| Daily totals:	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	
													kWh/kWp
Yearly totals:	730	876	1022	1168	1314	1461	1607	1753	1899	2045	2191	2337	
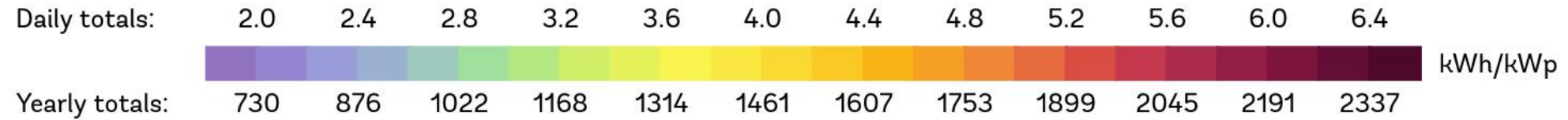
Solar
Wind
Water
Iron ore

Technology

Blast Furnace
Integrated
Direct Reduced
Iron
Electric Arc
Furnace

Criteria

+ Infrastructure Availability & Economic Relatedness

The Dilemma

Know-how in developed countries with deployed steel assets and industry

- Germany
- UK
- Japan

Resource beneficial locations with little infrastructure and economic relatedness

- Brazil
- Australia
- Namibia

The End

Thank you for listening