

Global Warming and the Steel Industry:

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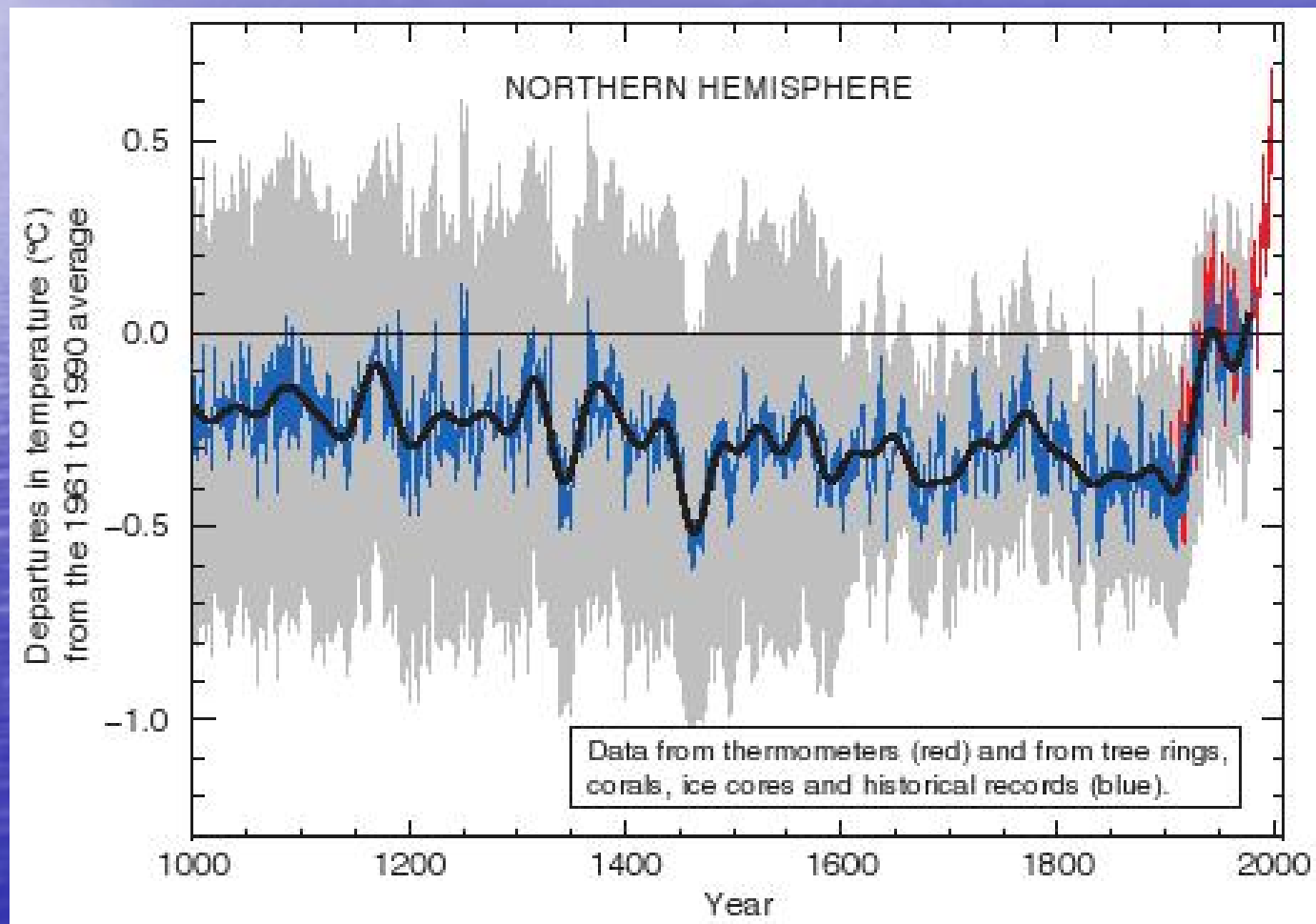
Global Warming: Fact or Fiction?

- Ross Gelbspan: “Unchecked, Global Warming will bankrupt the Global Economy by 2065.”
- No one can agree on what causes Global Warming, or how bad it is... Penn Jillette
- Bjorn Lomborg The Skeptical Environmentalist
- “If our understanding is based on myth, then we are likely to make bad judgments”

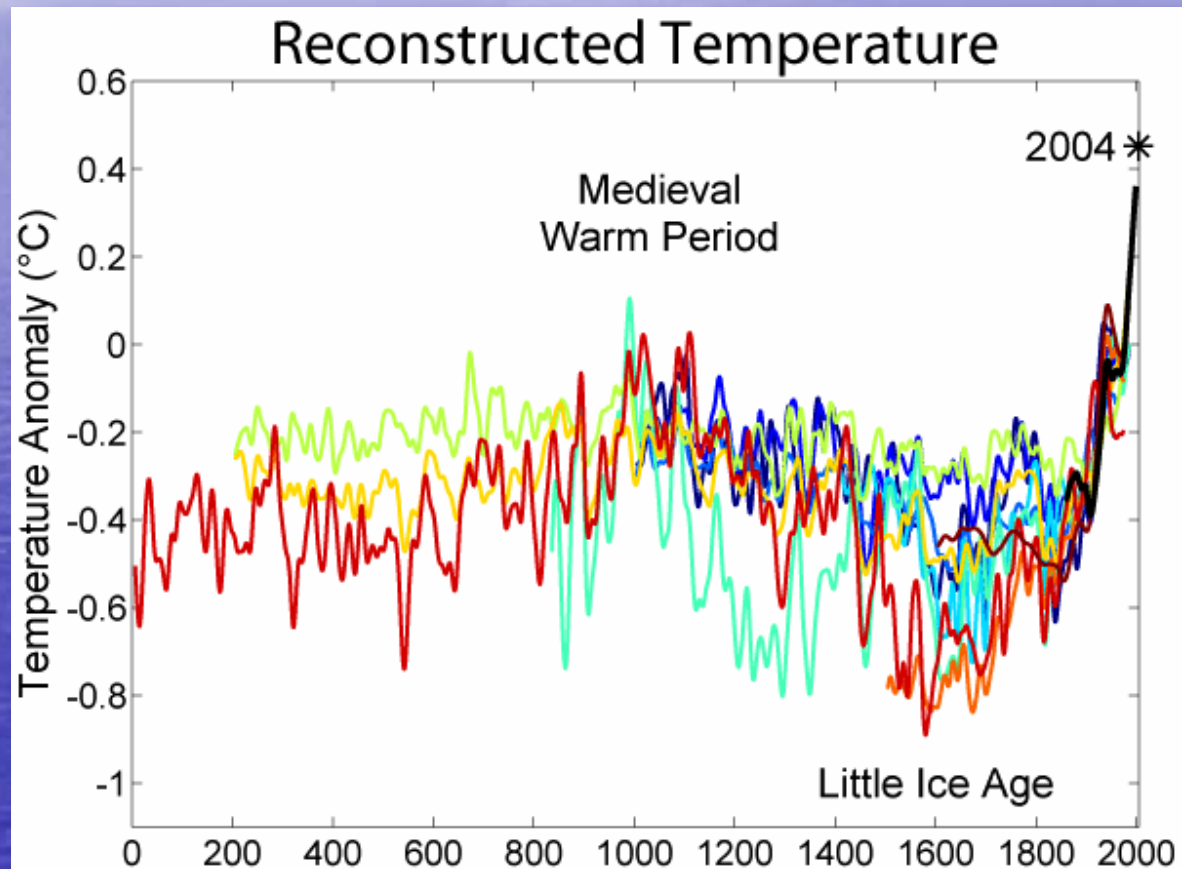
What is Global Warming?

- A perceived upswing in average air & water temperatures with time
- International Panel on Climate Change:
 - United Nations panel for this issue
 - The observed increase in the average temperature of the Earth's near-surface air and oceans in recent decades and its projected continuation. (Wikipedia)

The "Hockey Stick" Graph



Longer Timeline



Temperature Increase is Less than 1°C

- While the Timeline appears to reflect human influence, note the Error bar scales
- Neither the initial work, nor the criticisms have been peer reviewed!
- More on the meaning of the perceived trend to follow...

Global Warming comes in Two Flavors

- Natural Global Warming
- Anthropogenic (man-made) Global Warming

Natural Global Warming

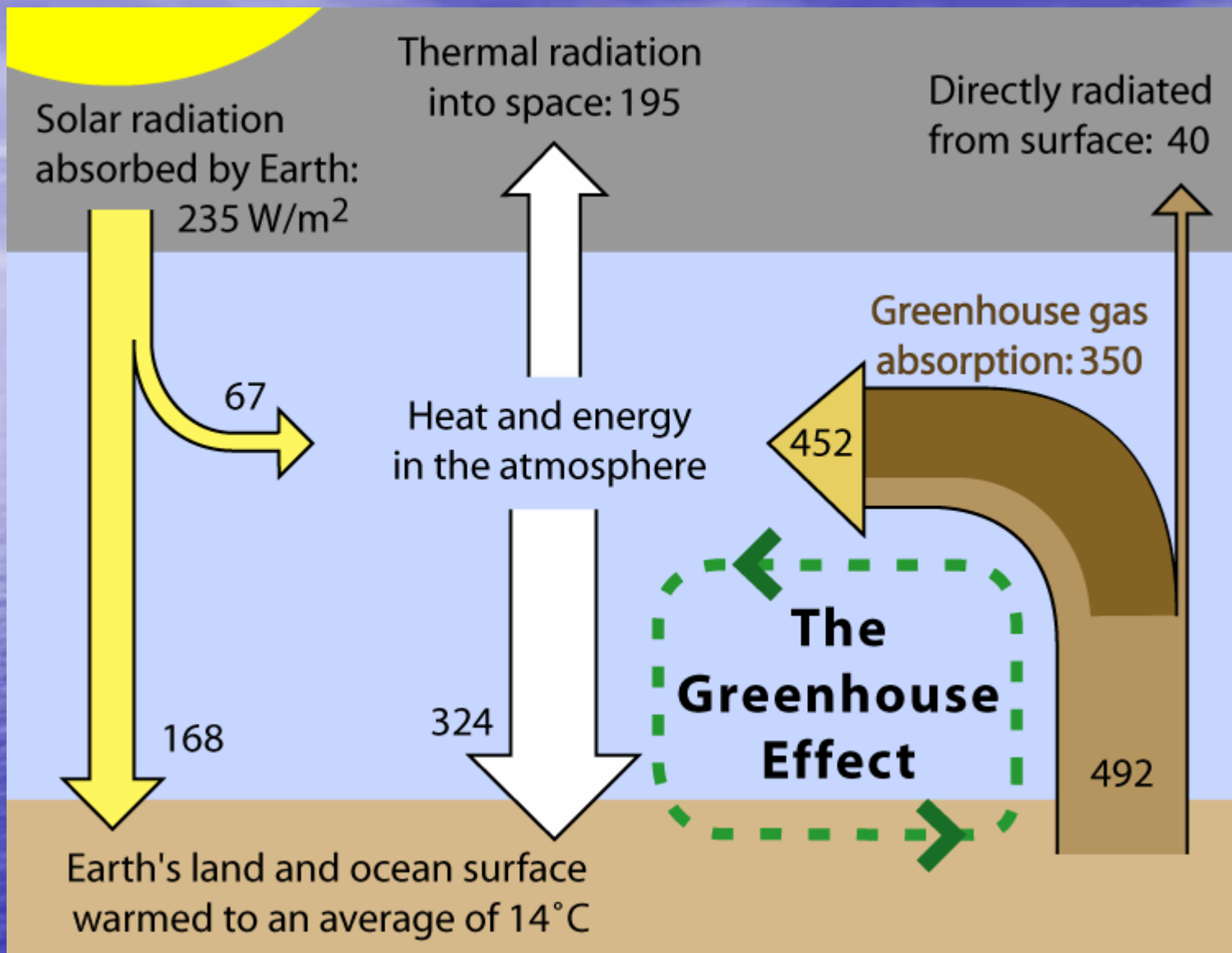
- Caused primarily by fluctuations in Solar Activity
- Offsets Ice Ages
- Data from planetary observations indicates increased solar output at the moment

AGW

- Caused by human activity
- Greenhouse Effect model
- Politically Charged debate

Greenhouse Effect Theory

- The gases in the Earth's atmosphere trap solar heat and reflect it back towards us
 - Joseph Fourier, 1824
 - Modeled by Svente Arrhenius, 1896
- Some of this is needed for habitability
- Is human activity driving this equilibrium?



NASA Values:

- Sun to Earth: 340 W/m^2
- Earth Back to Space: 100 W/m^2
- Net to Earth: 240 W/m^2
- Long-term (slow) losses also exist

What are the Greenhouse Gases?

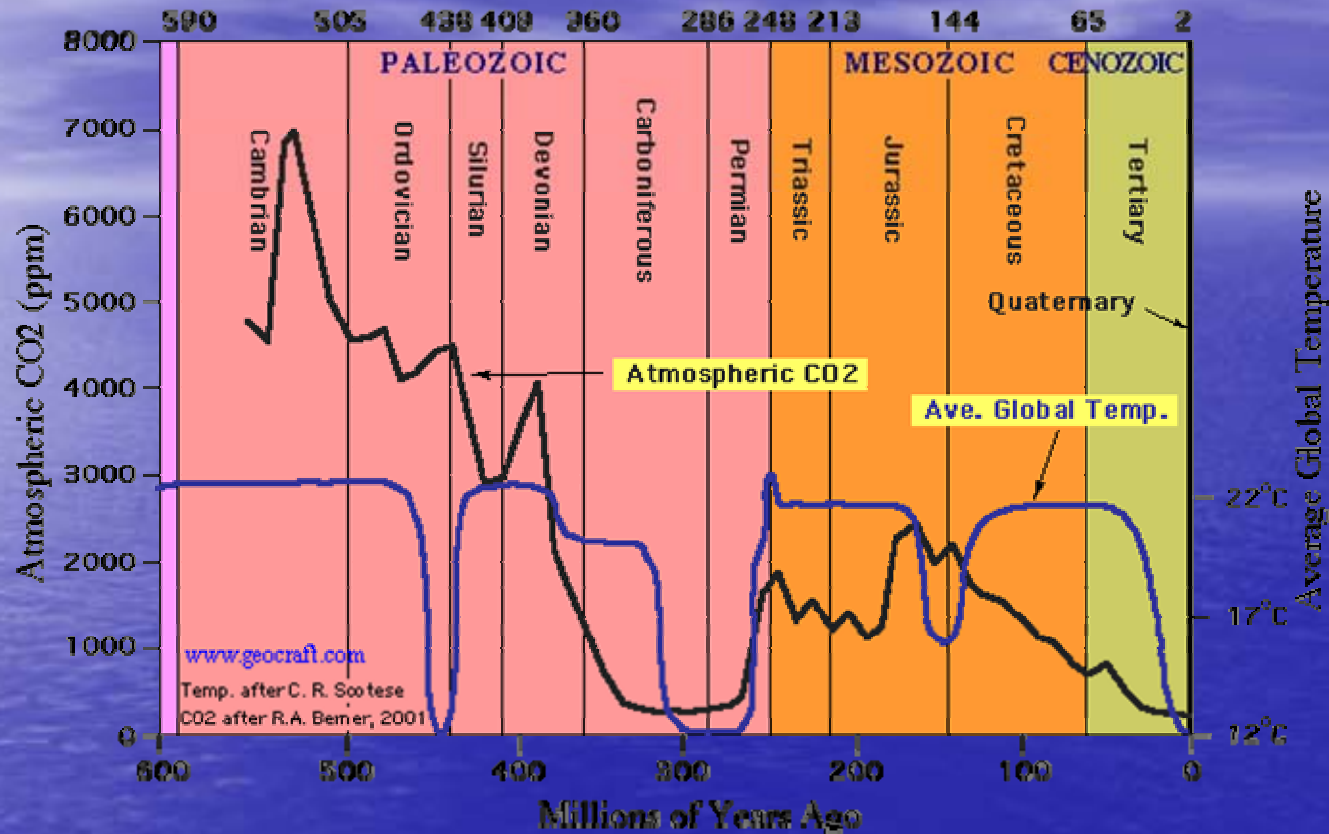
- Water vapor
- Carbon Dioxide
- Methane
- Nitrous Oxide
- CFCs

Water Vapor Predominates!

- Composition data is no longer readily available showing H₂O as % of total GHGs (80% - 90%)
- Add heat to the troposphere, and more water evaporates
- Climate models do not appear to reflect increased precipitation with increased evaporation. They tend to ignore the “Iris effect” whereby clouds control the heat flux – Balance between Cumulus and Cirrus
- Humans have only minor, local, affects on humidity – not an AGW issue

CO₂ gets all of the Press

- Also absorbs in the IR spectrum
- Pre-industrial: 280 ppm
- Now: 367 ppm
- Increase: 87 ppm, or 31%
- Needed by plant life (flora) for respiration
- Data for the Carboniferous Age
 - Early: 1500 ppm
 - Late: 350 ppm
 - Note the Carboniferous Ice Age!



Late Carboniferous to Early Permian time (315 mya -- 270 mya) is the only time period in the last 600 million years when both atmospheric CO₂ and temperatures were as low as they are today (Quaternary Period).

Temperature after C.R. Scotese <http://www.scotese.com/climate.htm>
 CO₂ after R.A. Berner, 2001 (GEOCARB III)

Relative Abundances:

- H₂O – 0.3% or parts per hundred
- CO₂ – 0.06%
- CH₄ – 1,700 ppb = 1.7 ppm
- N₂O – 314 ppb
- CFCs - ~1,000 ppt ≈ 1 ppb
 - IPCC figures

Forcing Factors for IR (W/m²)

- H₂O ~ 3.55
- CO₂ - 1.46
- CH₄ - 0.48
- N₂O - 0.15
- CFCs ~0.07

Removed absorbers	Fraction LW absorbed	Rad. Forcing Tropo. (W/m ²)
None	100%	0
H ₂ O	64 (64, RC78)	-56
Clouds	84 (86, RC78)	-
CO ₂	91 (88, RC78)	-23
O ₃	97 (97, RC78)	
Other GHG	98	-3
H ₂ O+Clouds	34	-
H ₂ O+CO ₂	47	-89
All except H ₂ O+Clouds	85	-
All except H ₂ O	66 (60-70, IPCC90)	-
All except CO ₂	26 (25, IPCC90)	-
All except O ₃	7	-
All except Other GHG	8	-
All	0%	-
Instant calculation, global mean, Jan. 1, 1979	RC78=Ramanathan and Coakley (1978)	
'All' includes aerosols, O ₃ and other minor gases as additional absorbers.		

From realclimate.org

Water Vapor is THE Greenhouse Gas!

See work done by Richard Lindzen
commentary for General Public at:
<http://earthobservatory.nasa.gov/Study/Iris/>

Note the combined IR forcing of CO₂ & H₂O

- CO₂ is manmade – or is it?
- Is it real – or is it politics?
- Kyoto Protocol is an effort to control CO₂ emissions – or is it?

CO₂

- Baseline of 280 ppm – natural
- Natural additions – 68 ppm (USDOE)
- Man-made additions – 12 ppm (USDOE)

CH₄ – USDOE data

- Baseline: 848 ppb
- Natural additions: 577 ppb
- Manmade additions: 320 ppb

- Other GHGs
 - too small to matter... <325 ppb

Politics of Kyoto

- China, India, developing nations exempt
 - India signed up anyway
 - PRC play numbers games
 - Russia ratified over scientific objections
- EU cannot meet its goals... Except by counting restructuring of Eastern Europe from Soviet era technology... Collapse post 1990
- It sure doesn't look smart from the US point of view...

Whatever happened to Global Cooling?

- In the 1970s, there was increasing awareness that estimates of global temperatures showed cooling since 1945
- How the times have changed
- The sun goes through cycles of increasing and decreasing radiation output. Warm periods and ice ages.

Volcanoes could make another Ice Age

- SO_2 in the Stratosphere blocks IR transmission to Troposphere...
- Some AGW advocates want to launch rockets with SO_2 payloads to reverse the "trend"

CO₂ in the Steel Industry

- We use Carbon as a reducing agent in our furnaces
 - Coke production and Blast Furnaces
 - Slag Foaming and Melt Chemistry
 - DRI Reactors – Solid or Gas hydrocarbon feedstocks
- We use Natural Gas to fire burners
- We use electricity
- We use transportation

CO₂ in the Steel Industry

- DOE's OSTI has commissioned several reports since 2000
 - From the Charles River Associates Report of 2001

SUMMARY OF FINDINGS

The iron and steel industry is a significant emitter of carbon dioxide, with emissions totaling 185 million tons in 1998. In the last decade, the industry has made significant progress in decreasing the specific carbon dioxide emission rate from almost 210 million tons, or 2.2 tons per ton of steel to 1.7 tons per ton of steel. Further reductions in carbon dioxide emissions may be possible through judicious adoption of various proposed technologies.

Fruehan⁴ et al. analyzed the CO₂ emissions for various unit process steps in the production of steel. This analysis was designed to put a theoretical, lower limit on the carbon dioxide emissions and is a good road map. However, there are practical considerations, such as heat losses, process inefficiencies, and other unavoidable losses, which preclude the achievement of theoretical values.

We may be able to reduce energy consumption significantly by our current drive to be more cost efficient – needs technological innovation to achieve ~10% per year

Taking 1990 as a base year, Stubbles shows that the average specific energy consumption in the industry had been reduced by 50 percent since 1950, due mainly to greatly reduced blast furnace fuel rates; the replacement of open hearth furnace/ingot casting technology with basic, oxygen furnace/continuous casting technology; and the increased production of steel from scrap in electric arc furnaces. His projection of ongoing decreases in specific energy consumption of 13 percent by 2000 from the 1990 levels incorporates the suite of assumptions described above. However, only about 35 percent of the total is attributed to the structural change in the industry caused by the loss of share in the integrated sector, so that about 9 percent must be technology-driven. There is a finite supply of high-quality scrap, and additional iron units must be generated from the reduction of virgin iron ore to satisfy the overall U.S. demand for high-quality, low-residual flat rolled steel, and this will mitigate the savings achievable by simple structural changes. Overall, CRA's projection of savings of up to 10 percent through new policy-driven incentives is only slightly more aggressive than that projected by Stubbles on a "business-as-usual" basis. This holds true against either current, best-practice performances, as well as other new developments in technology in the U.S. or elsewhere.

Which of these can WE control?

- Reducing Agents – limited by the need to make a suitable product
- Furnace Fuels – limited by the need to meet temperatures
 - Melting
 - Plasticity - rolling
- Electricity – CO₂ control is the utilities concern – until it affects the rates!
- Transportation: Zero Emission Vehicles don't exist. Lower vehicle emissions, more electrification for in-plant use...

AISI Launched R&D Initiative in 2003

- 4 University research programs
 - Missouri-Rolla – Geological Sequestration of CO₂
 - Utah – Hydrogen Flash Smelting
 - Columbia - Integrating Steel Production with Mineral Sequestration
 - MIT – Molten Oxide Electrolysis

Europeans got Rolling in 2005

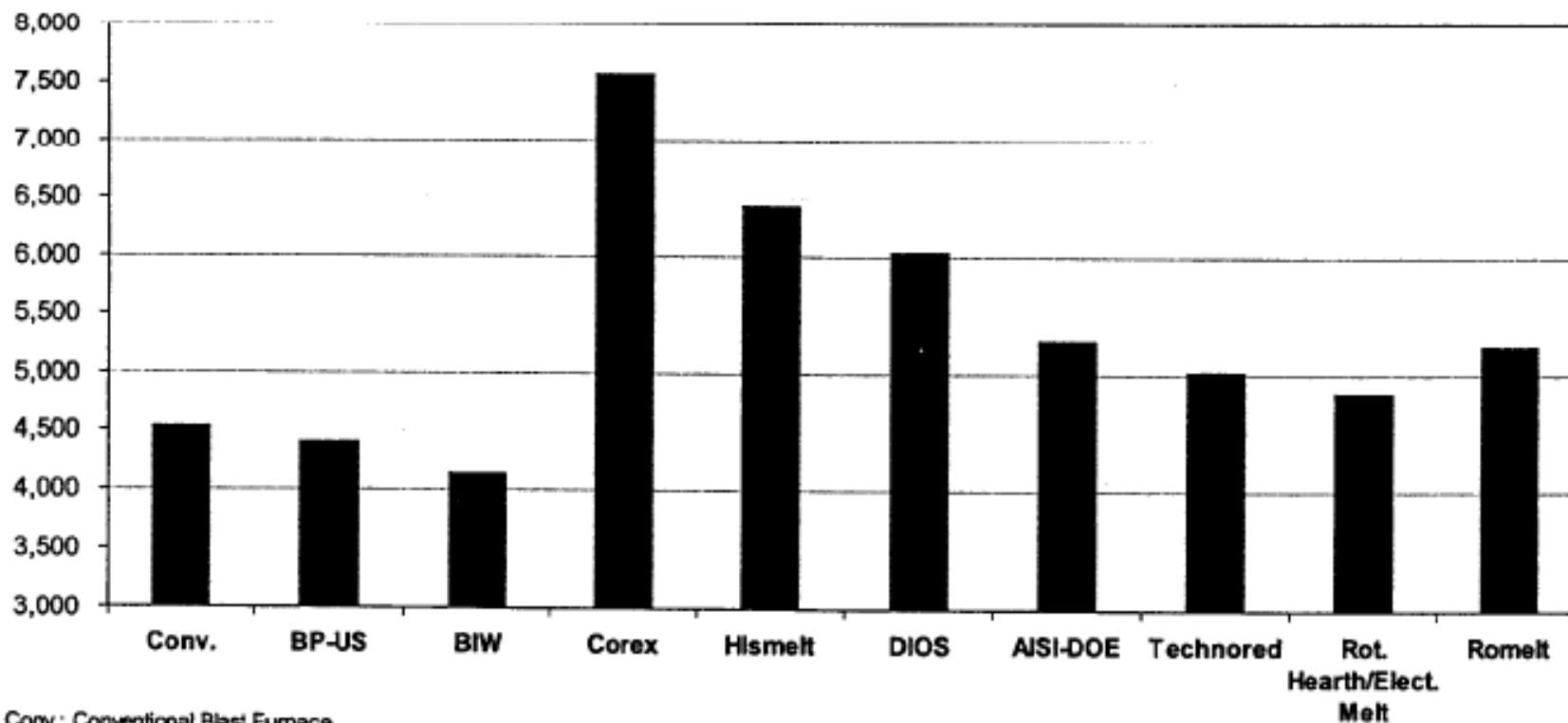
- The initiative will start with a five-year exploratory phase, which should be followed by a pilot phase lasting for another five years before commercial implementation can be considered.

Finally...

- If you can't beat 'em...
 - Anyone for an algae bloom?
 - Seed the oceans with iron ions
 - Algae ponds on exhaust stacks
 - Some algae makes oils for bio-diesel...

Figure S2. Carbon Dioxide Emission Level: Smelting Processes

CO₂ Emission Level (Pounds per Ton Hot Metal)



Conv.: Conventional Blast Furnace

BP US: Best Practice U.S.-Blast Furnace

BIW: Best Practice in the World-Blast Furnace

Source: Charles River Associates, 2001.