



American Iron and Steel Institute

Technology-driven Response to Climate Change

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Stanford GCEP Workshop

April 16, 2008

About AISI

- ✧ A century old trade association comprised of:
 - Producer member companies
 - integrated, electric furnace, and reconstituted mills
 - Associate member companies
 - suppliers to or customers of the industry
 - Affiliate member organizations
 - downstream steel producers of products such as cold rolled strip, pipe and tube, and coated sheet.

- ✧ AISI member companies account for more than 75% of the raw steel produced in North America.



AISI Mission

"To influence public policy, educate and shape public opinion in support of a strong, sustainable U.S. and North American steel industry committed to manufacturing products that meet society's needs."

Why reduce GHG emissions?

- ❖ The steel industry currently generates about 6% of the world's greenhouse gas (GHG) emissions
- ❖ The vast majority of the industry's greenhouse gas emissions are associated with its energy consumption, either through the direct combustion of fossil fuels or the use of electricity generated from fossil fuels
- ❖ Energy costs represent 15–20% of the total cost to produce steel
- ❖ Carbon is needed to physically make steel,
STEEL = Iron + Carbon



Investments in Technology

- ✧ Since 1975, the steel industry has invested over \$60 billion in new technologies to improve energy efficiency and productivity
- ✧ In a typical year, > 15 % of the steel industry's capital expenditures (over \$23 billion in 2003 and 2004) are directed toward environmental facilities
- ✧ North American Steel industry is investing millions of dollars to develop CO₂ Breakthrough Technologies



Carbon Management Approach

- ✧ Technology-driven solutions
- ✧ Globally-focused on:
 - Improving energy efficiency
 - Reducing emissions
- ✧ Voluntary initiatives:
 - Climate VISION
 - Asia Pacific Partnership
 - IISI & AISI CO₂ Breakthrough Programs



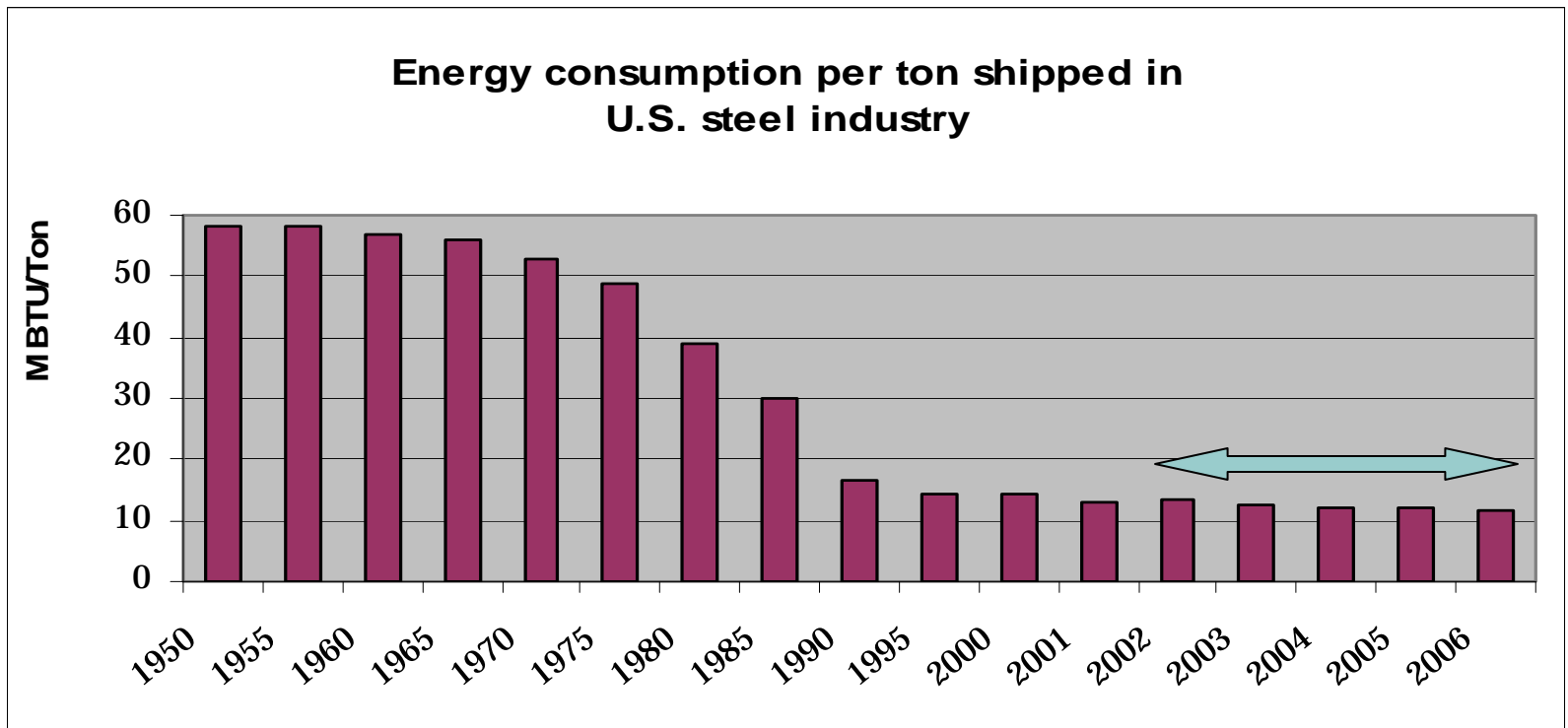
US-DOE Climate VISION Program

(Voluntary Innovative Sector Initiatives: Opportunities Now)

- ✧ A portfolio of federal and voluntary programs aimed at reducing GHG intensity by 18% between 2002-2012
- ✧ A sustained effort to:
 - Advance climate change science
 - Accelerate technology development and commercialization
 - Promote international collaboration

AISI Climate VISION Goal

“a 10% improvement in energy intensity from 2002 to 2012.”



Source: U.S. Dept. of Energy and AISI

The Steel industry has already achieved that reduction in just four years!



Asia Pacific Partnership

- ✧ Seven nation effort working toward technology based solutions for energy and CO₂ reductions via:
 - Sharing of Best Practices
 - Transforming Markets
 - Facilitating Investments
- ✧ State-of-the-Art Clean Technology Handbook published January 2008 by steel task force

CO₂ Breakthrough Programs

- ✧ International Iron & Steel Institute Breakthrough program
 - Separate global research clusters
 - Communicate progress through IISI
 - North American cluster is organized under AISI
- ✧ AISI Breakthrough Program
 - Technology-driven solutions that are expected to achieve significant CO₂ reductions
 - Two pilot scale technologies in development
 - One demonstration project in design phase



AISI Breakthrough Program

Pilot-scale Technology

Suspension Hydrogen Reduction of Iron Oxide Concentrate *(University of Utah – Sohn)*

Goal:

- ✧ To develop an ironmaking process based on:
 - Hydrogen as a reducing agent and as a Fuel in a suspension reduction process drastically reducing or eliminating CO₂
 - Eliminating coke making, pelletizing / sintering

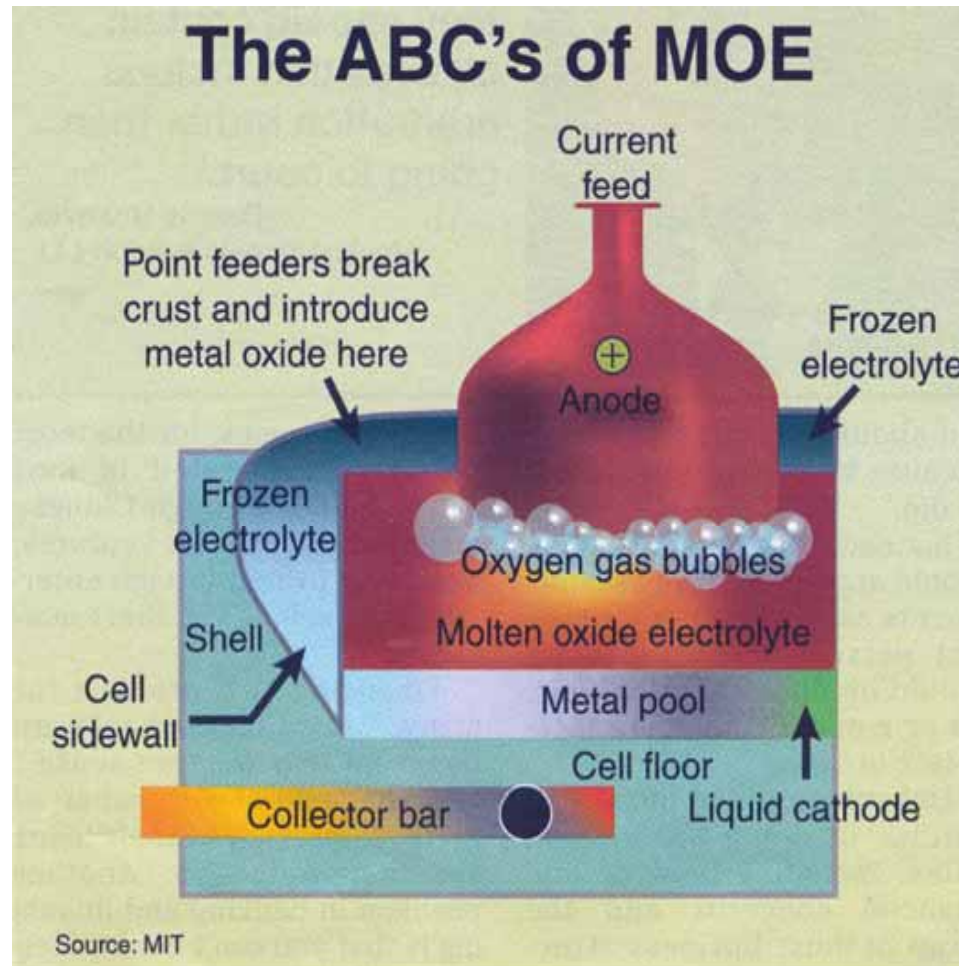
Suspension Hydrogen Reduction of Iron Oxide Concentrate

Status:

- ✧ January 2008 - Initiated a three year, project with emphasis on pre-pilot scale tests focusing on:
 - Fuel / Reductant Usage
 - Evaluate and Select Suspension Technologies
 - Heat and Mass Balance
 - Plant Flow sheet
 - Capital and Operating Cost

Steelmaking by Molten Oxide Electrolysis

(MIT – Sadoway)



Molten Oxide Electrolysis

Goal:

- ✧ Assess the technical viability of the production of iron by molten oxide electrolysis
- ✧ Identify inert anode and its ability to sustain oxygen evolution
- ✧ Demonstrate production of liquid iron by electrolysis in laboratory-scale cell



Molten Oxide Electrolysis

Status:

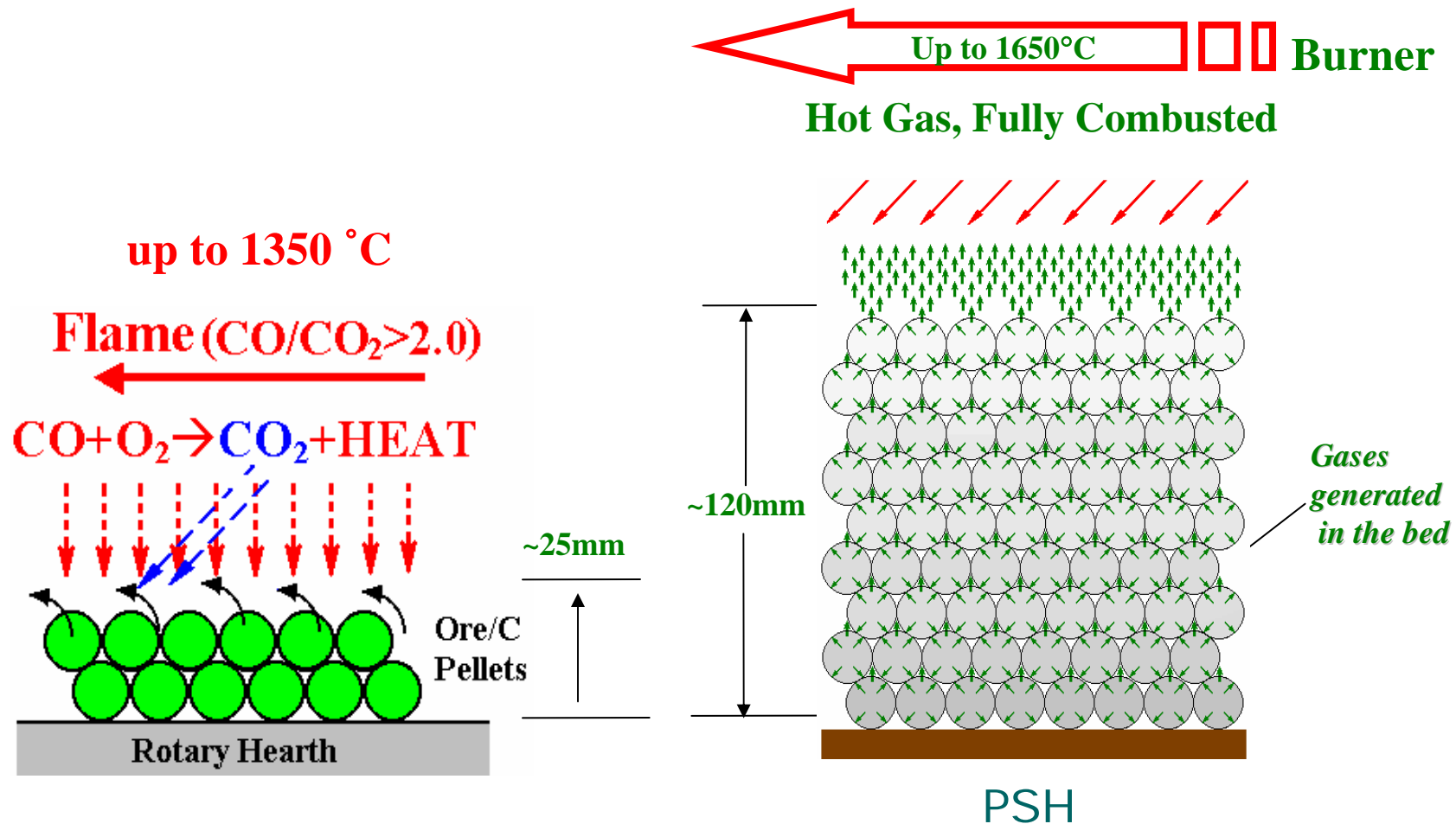
- ✧ January 2008 - Initiated a 2 year, project to Build Pre-Pilot Cell:
- ✧ Focusing on:
 - Efficiency, Temperature, Voltages
 - Process Operating Costs
 - Process Parameters



AISI Breakthrough Program

Technology in demonstration
phase

Paired Straight Hearth (PSH) Furnace





Paired Straight Hearth Furnace

Phase 1 Goal:

- ❖ Demonstrate technology at near-commercial scale
- ❖ Develop an Alternative to Blast Furnaces and Coke Ovens
- ❖ Provide Hot Metallic Iron for Smelting and EAF Steelmaking



Paired Straight Hearth Furnace

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Paired Straight Hearth Furnace

Phase 1 plan:

- ❖ Conduct six-month pelletizing test at Coleraine Material Research Lab
- ❖ Develop minimal design criteria for 45,000 tpy demonstration plant
- ❖ Confirm Host site
- ❖ Start construction – Fall 2008
- ❖ Demonstrate technology at near-commercial scale



Paired Straight Hearth Furnace

Phase 2 Plan (2012):

- ✧ Couple PSH furnace to the AISI Smelter
- ✧ Demonstrate PSH-Smelter combination at scale
- ✧ Successful completion of these two steps would result in a viable blast furnace/coke oven replacement technology available within the steel industry's first decision window for blast furnace relines



AISI Breakthrough Program

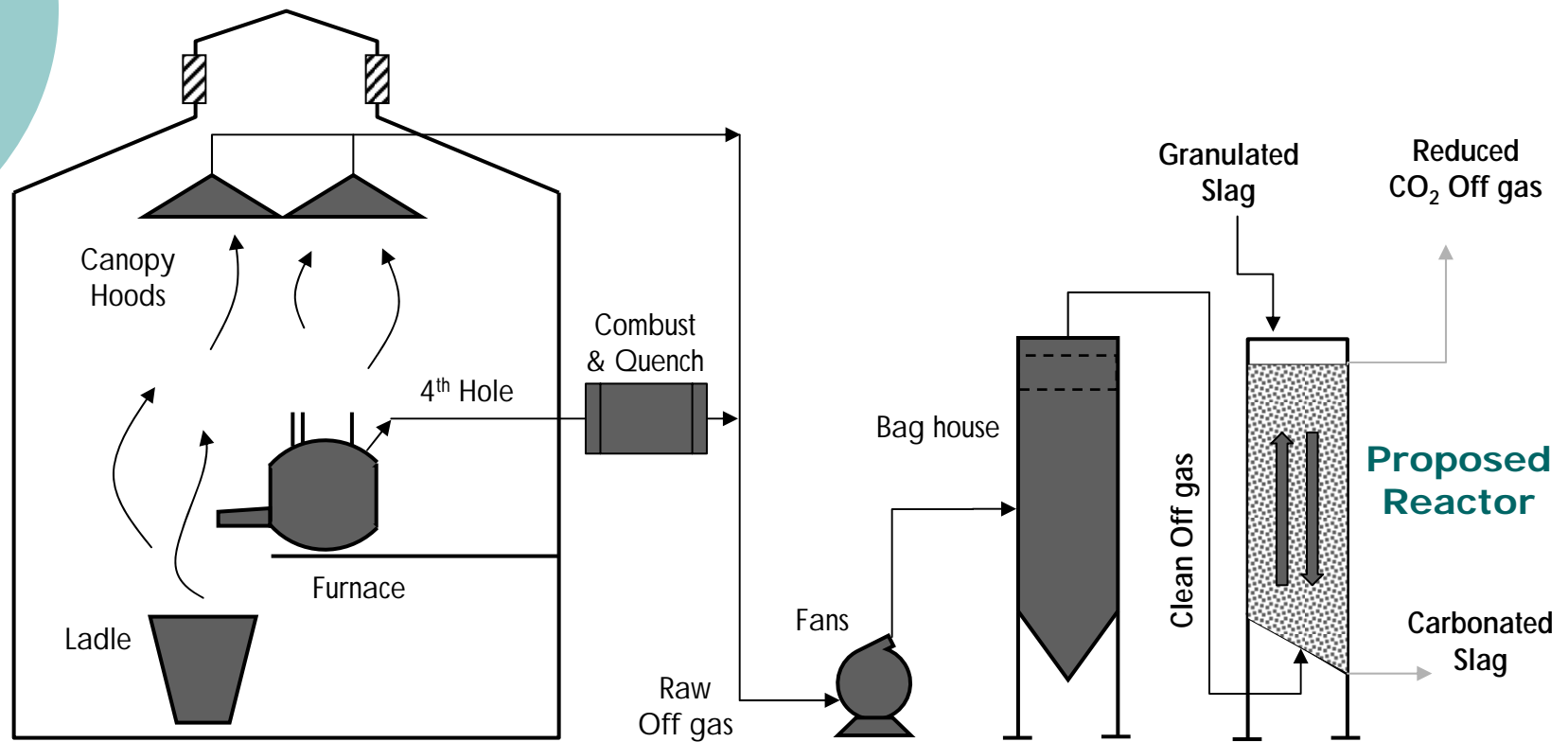
Technology being Evaluated

Geological Sequestration of CO₂ with Slag *(MST – Von Richards)*

Goals:

- ❖ Utilize steelmaking off-gas to rapidly carbonize (age) slag for beneficial re-use
- ❖ Capture and concentrate undesirable trace elements that may appear in slag
- ❖ Reduce CO₂ emissions from steelmaking by up to 85%

Geological Sequestration of CO₂ with Slag



(EAF Application Shown)

Geological Sequestration of CO₂ with Slag

Progress:

- ✧ Developed gas-liquid-solid kinetic model
- ✧ Completed bench-scale validation utilizing
 - two-stage slurry reactor
 - gas bubbling reactor
- ✧ Evaluating for further scale-up:
 - Continuous Ca leaching by fresh water
 - Direct carbonization in a two-stage process
- ✧ Potential deployment in production beginning 2012

Integrating Steel Production with Mineral Sequestration *(Columbia – Lackner)*

Goals:

- ✧ Significant reduction of CO₂ emissions
- ✧ Develop a “carbon sink” within the steel industry and sell CO₂ disposal credits to other industries
- ✧ Beneficial use of iron oxides from peridotite ores



Integrating Steel Production with Mineral Sequestration

Progress:

- ❖ Completed comprehensive review of serpentine dissolution techniques
- ❖ Developed kinetic model describing serpentine dissolution under varying conditions of temperature, pH, and solvent composition



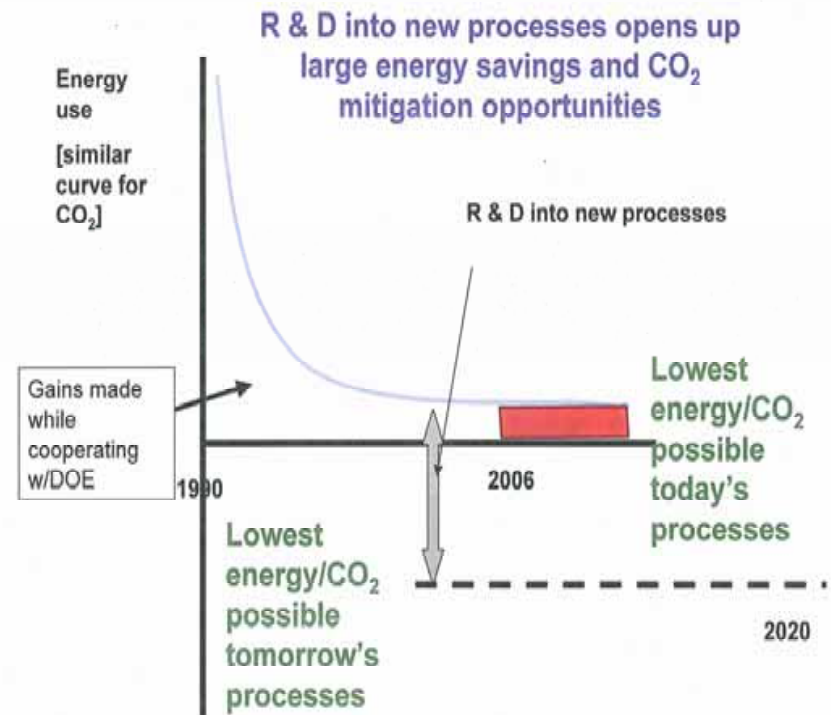
Integrating Steel Production with Mineral Sequestration

Future Plans

- ✧ Perform additional dissolution experiments
- ✧ Rigorous thermodynamic and process yield calculations
- ✧ Complete Economic analysis
- ✧ Finalize technical report on iron recovery

Climate Change Progress

- ✧ Since 1990, the U.S. steel industry has reduced its energy intensity per ton of steel shipped by 27%.
- ✧ Since 2002, energy intensity is down 15%.
- ✧ During the same period, aggregate CO₂ emissions per ton of steel shipped were reduced by a comparable amount





American Iron and Steel Institute

“ We long ago recognized our responsibility to reduce emissions and energy intensity. We have done so – and we continue to do so – through our support for **breakthrough technologies**, which provide the ultimate answer to the climate issue.”

Louis L. Schorsch
CEO ArcelorMittal Flat Carbon Americas,
Vice Chairman AISI