ArcelorMittal

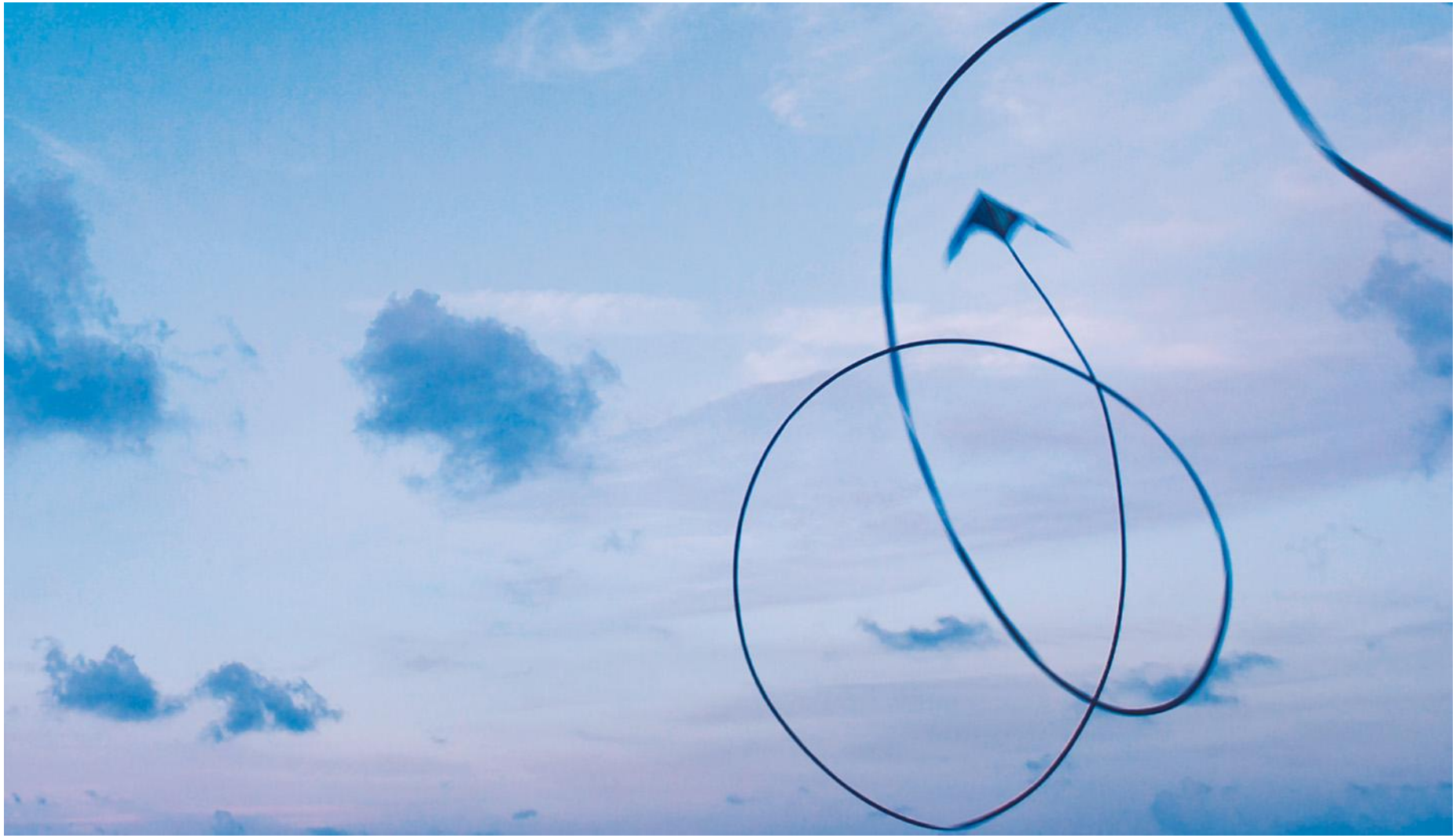
Steel Production and the Industrial Economy
CCTR Presentation

December 12, 2008

Contents

- Scale of the Steel Industry
- Relation of Coal and Steel Production
- Iron Processes and Carbon Need
- Impact in Indiana
- Future Technologies
- Conclusion

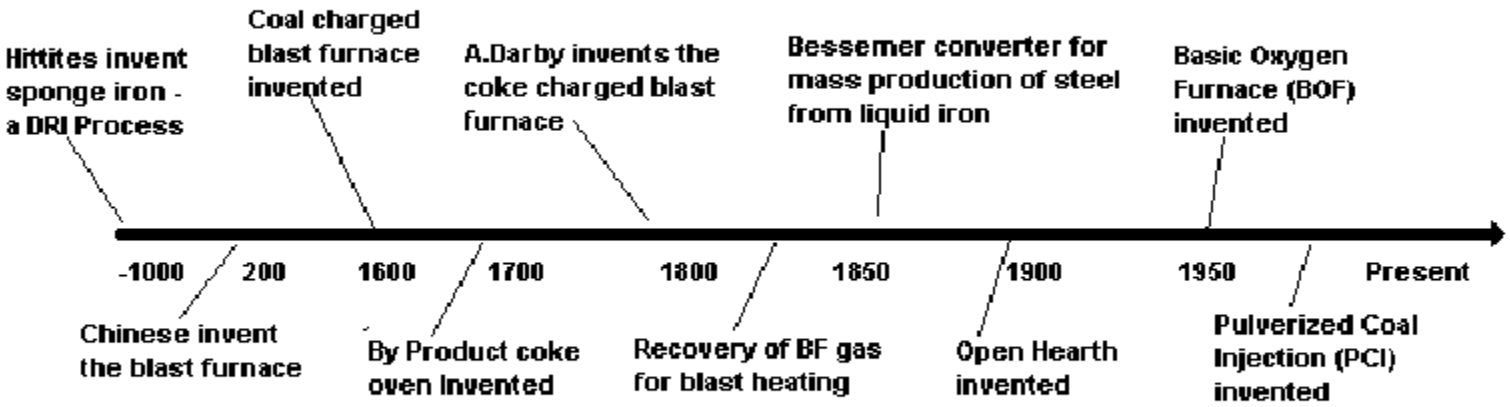
The World Steel Industry



Steel

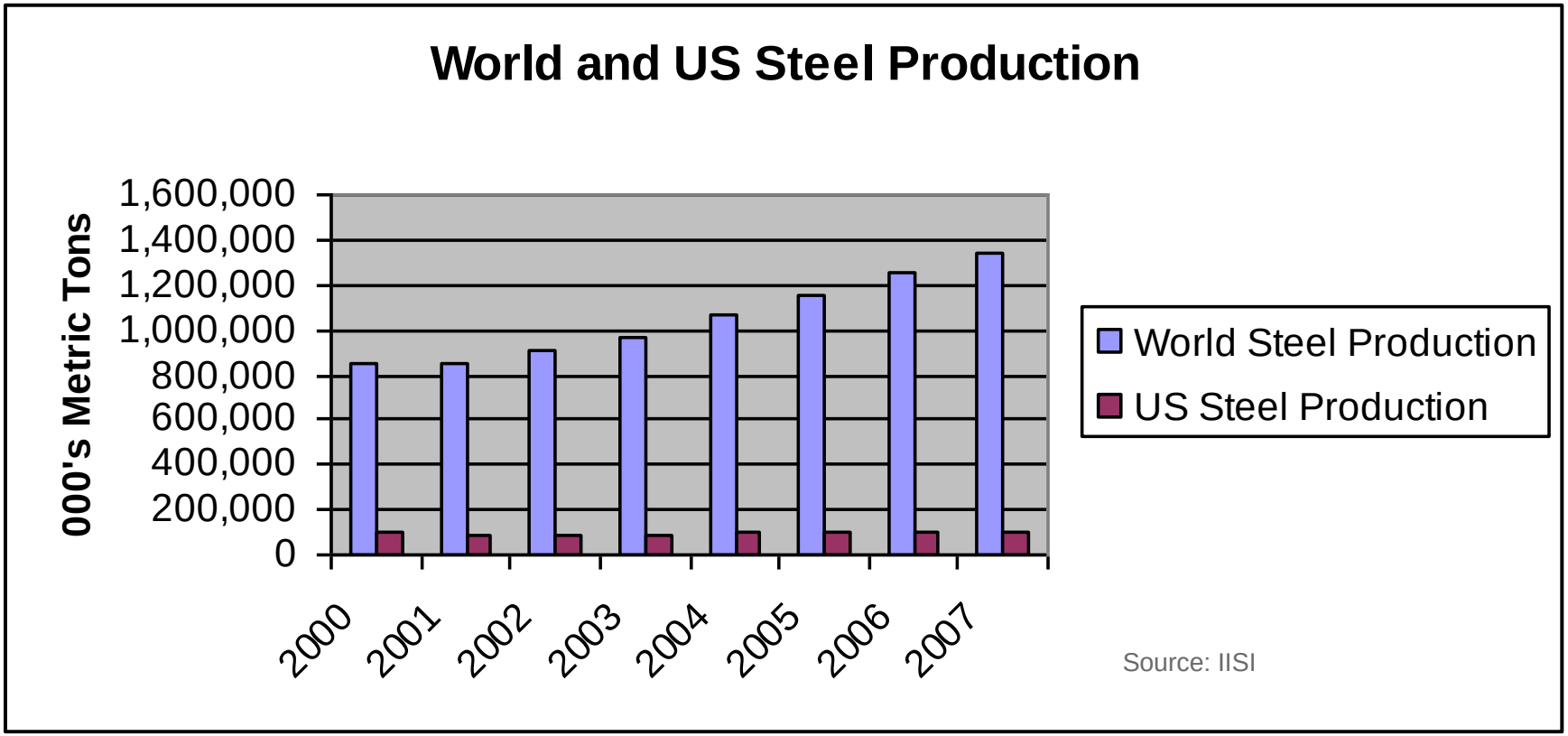
- Steel and its iron precursors have been the key metal in society since approximately 1000 B.C.
- Steel production is the 4th largest industrial activity after power generation, cement manufacture and petroleum refining.
- Total steel production has reached 1.4 billion tons annually.
- The United States produces about 100 million tons – 7% of the world total.
- Steel is broadly used in construction, machinery, transportation, appliances.

Steel Timeline



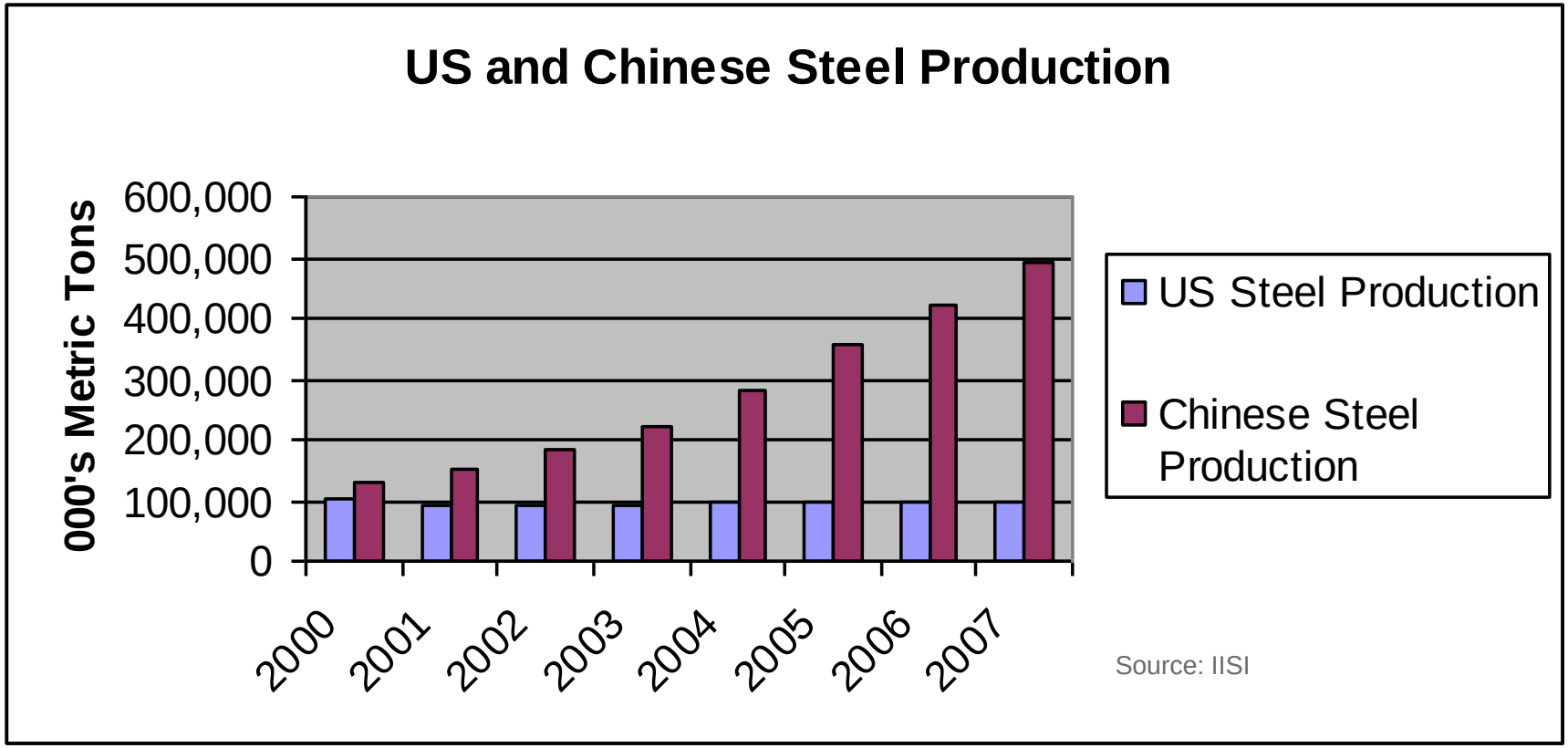
World Steel Growth

- Since 2000 world steel production has been growing 8% annually
- Steel Production in the US has been essentially flat.

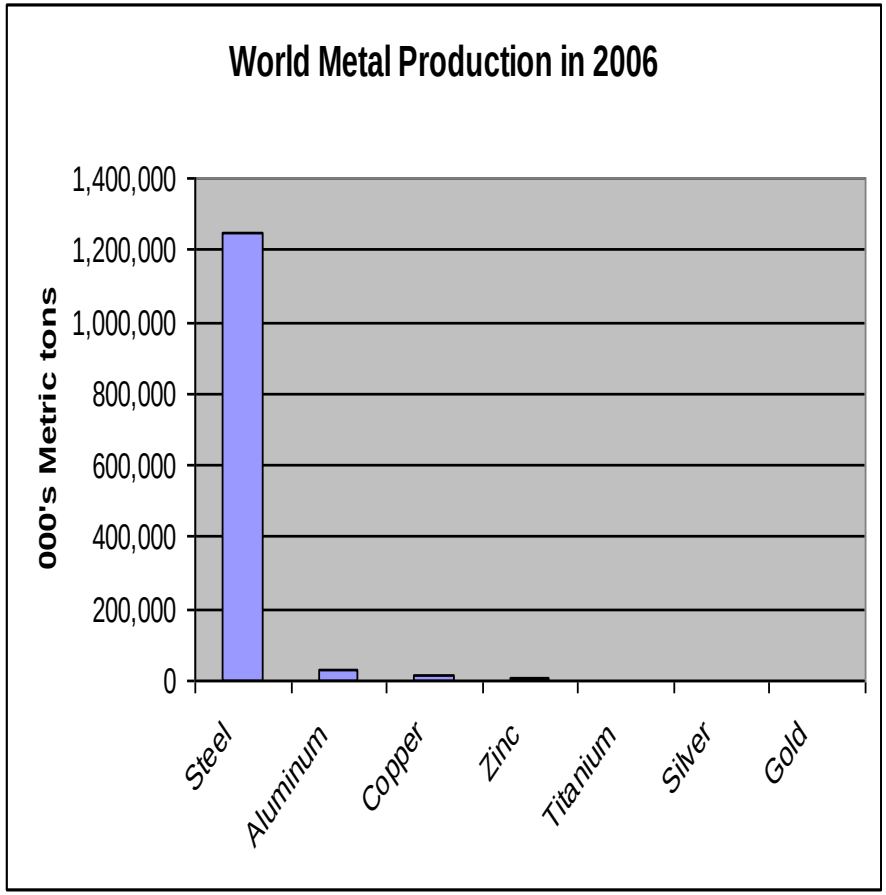


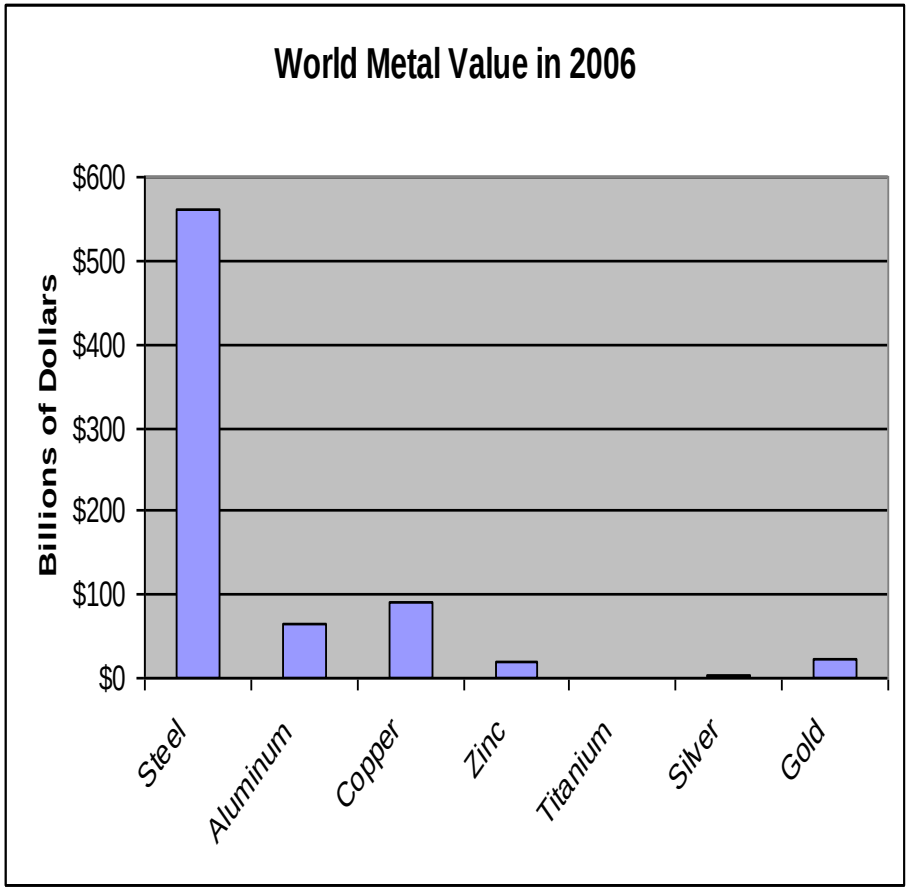
Chinese Steel Growth

- China has been the driver of steel growth.
- There also have been significant increases in Brazil and India



Steel Compared to Other Metals





Source: USGS

Relation of Coal and Steel Production

The source of Iron

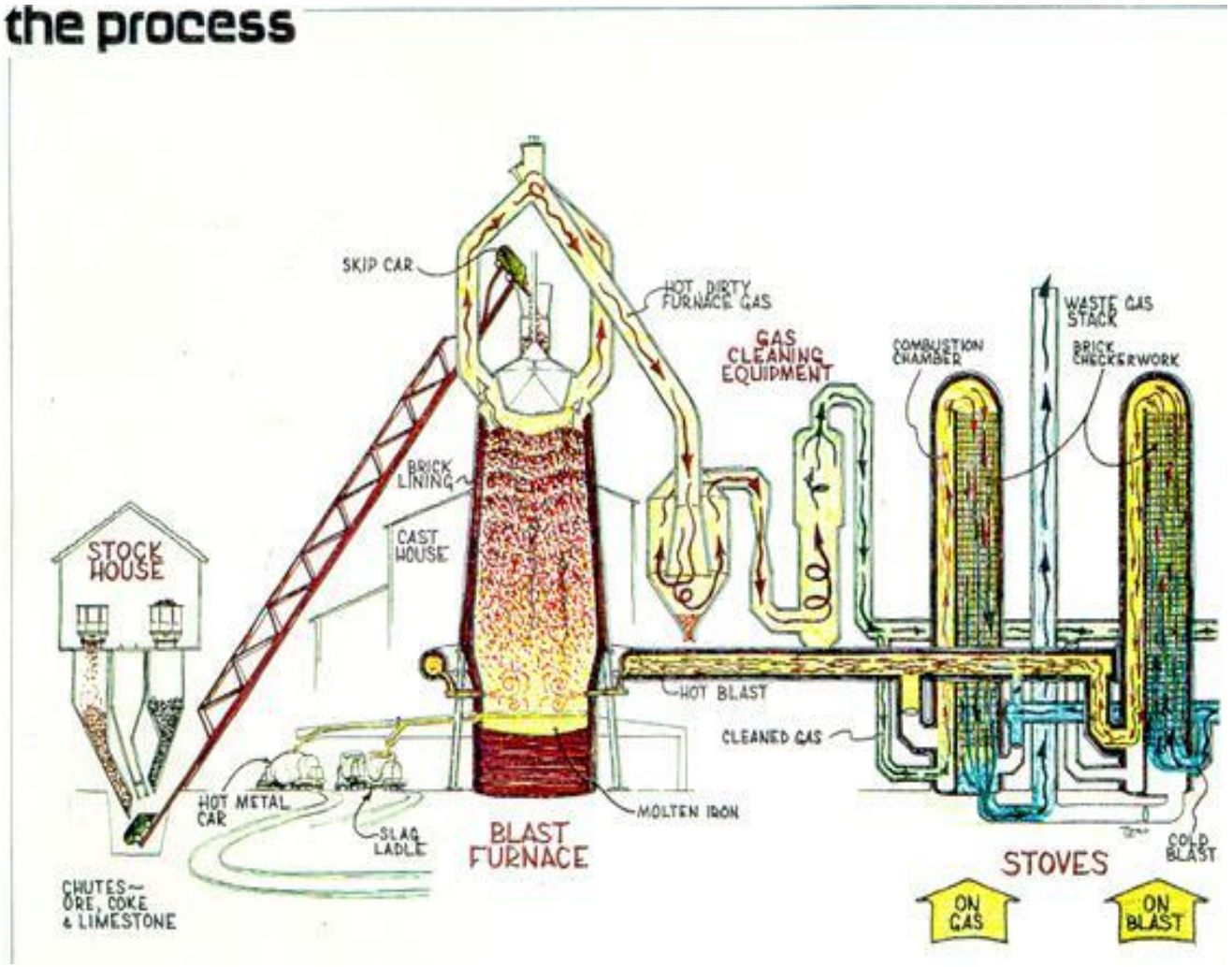
- Iron is very abundant. It is the most common element on Earth and the 4th most common in the Earth's crust.
- Because Iron reacts with oxygen, there is essentially no natural metallic iron present near the surface of the Earth
- Iron is obtained from ores that were created when the atmosphere of the Earth changed from reducing to oxidizing between 1 and 2 million years ago.
- Almost all iron ore is either Hematite Fe_2O_3 or Magnetite Fe_3O_4
- The ore mined in the US is called Taconite – a fine grain mixture of Magnetite and Silica.
- To obtain metallic iron, the oxygen must be removed from the ore.

Reduction of Iron

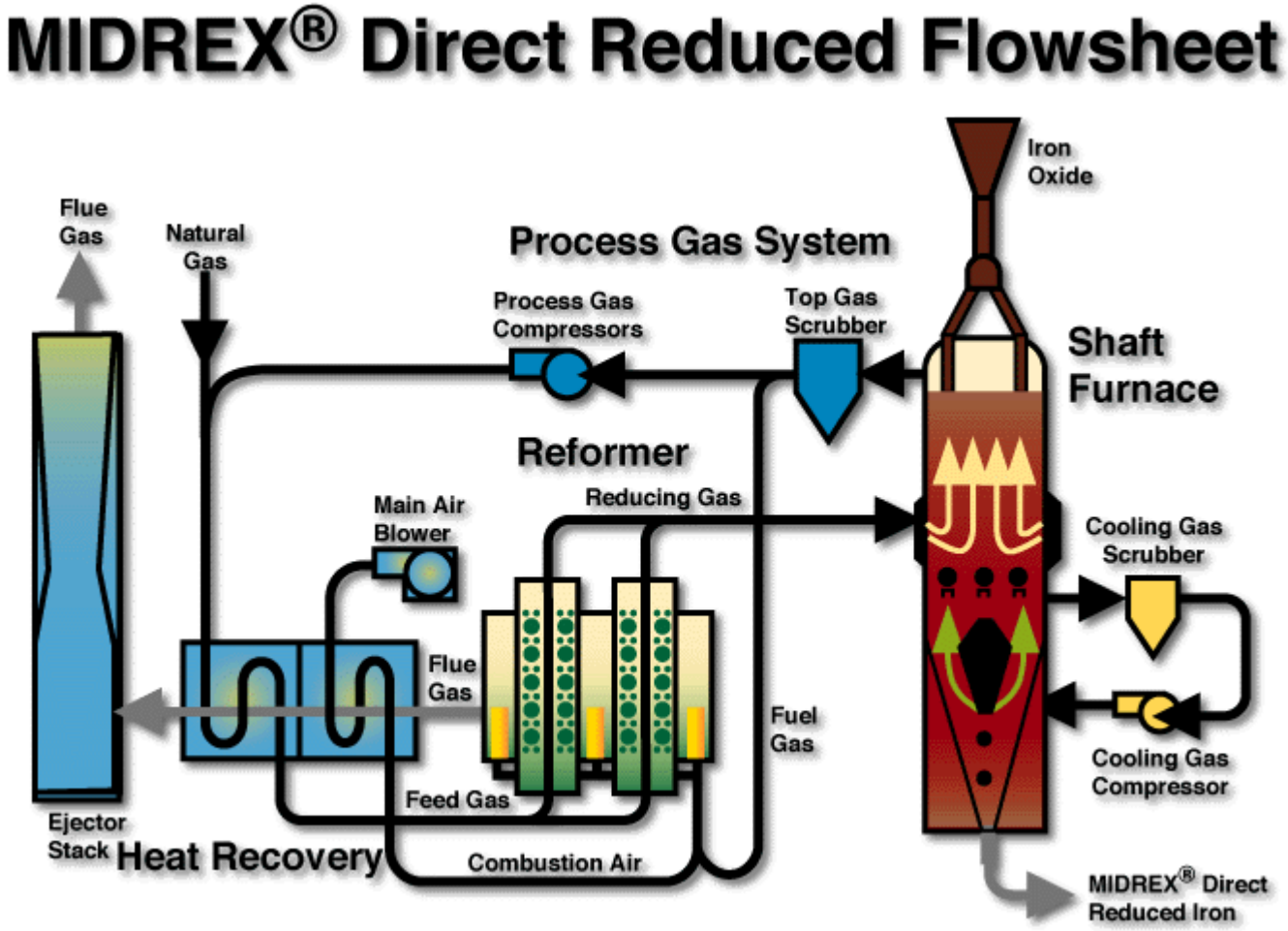
- The oxygen must be removed from the ore chemically. This is called reduction.
- There are two practical ways to do this:
  - With carbon
  - With hydrogen
- Both methods require elevated temperatures greater than 1600 degrees to work.
- Almost all the iron made by carbon reduction uses the blast furnace process to produce a liquid iron that goes into the BOF
- Almost all the iron made by hydrogen reduction goes through the Direct Reduction process and produces a product that is used like scrap in the Electric Furnace.

Iron Processes

Blast Furnace

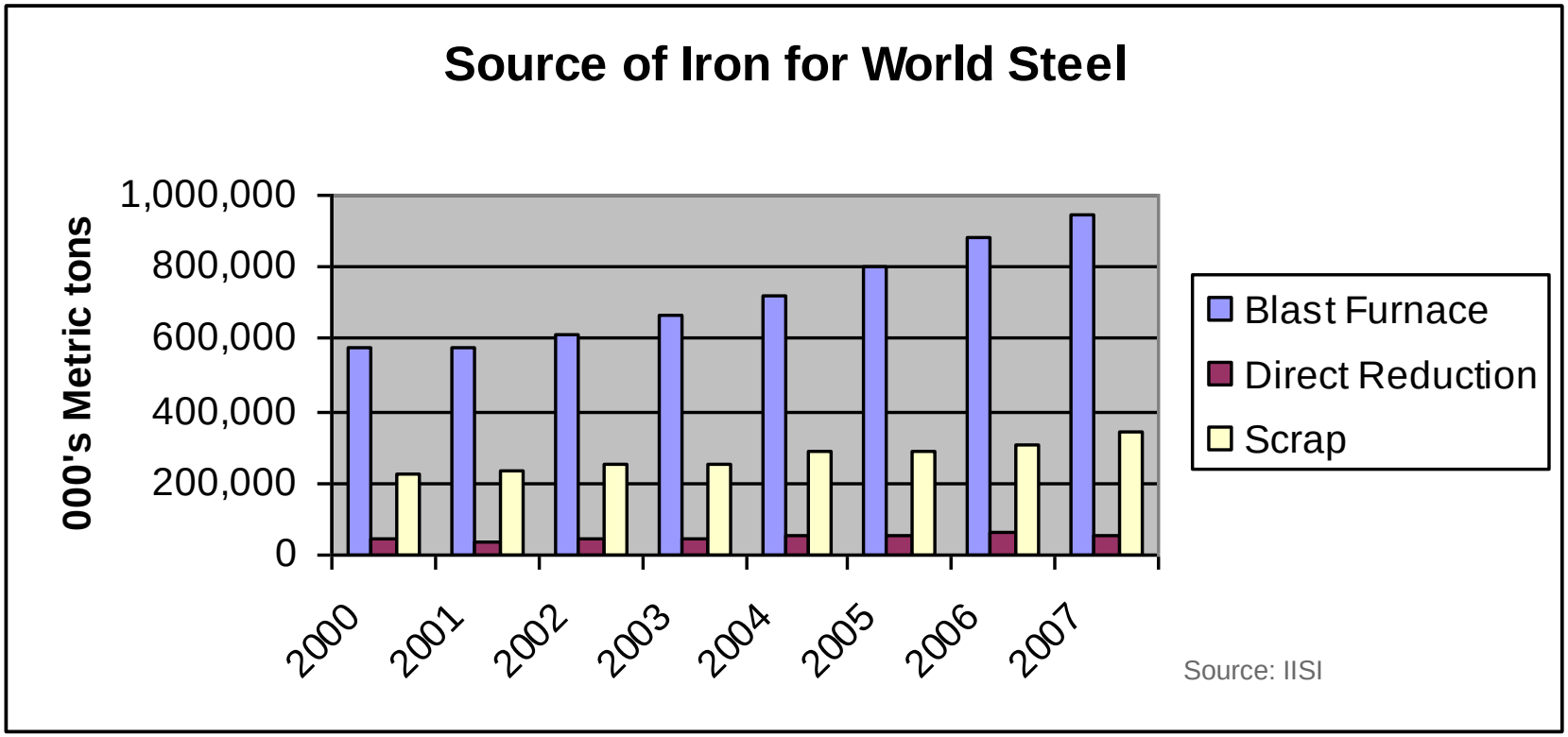


Direct Reduction



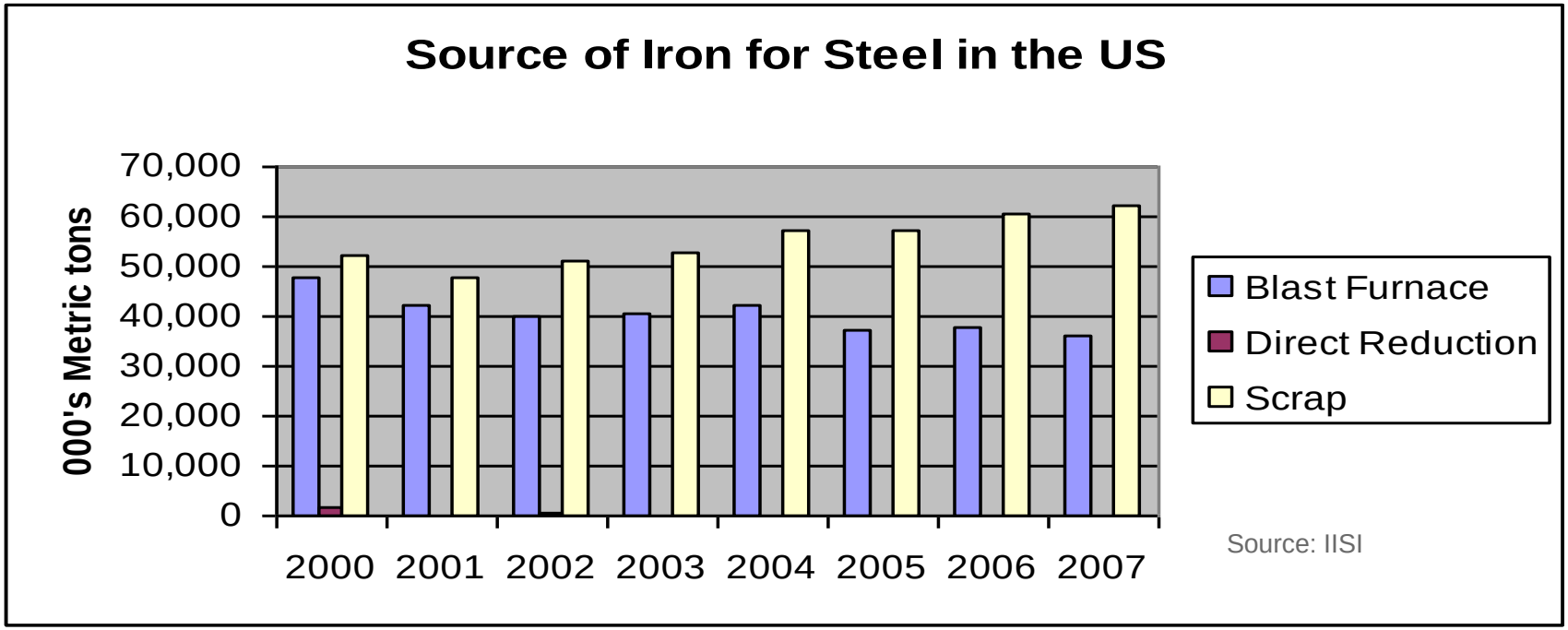
Comparison of Iron Sources

- Steel is the most recycled material on Earth but all scrap originally had to come from iron ore.
- Blast furnace iron is the source of 95% of new metallic iron.



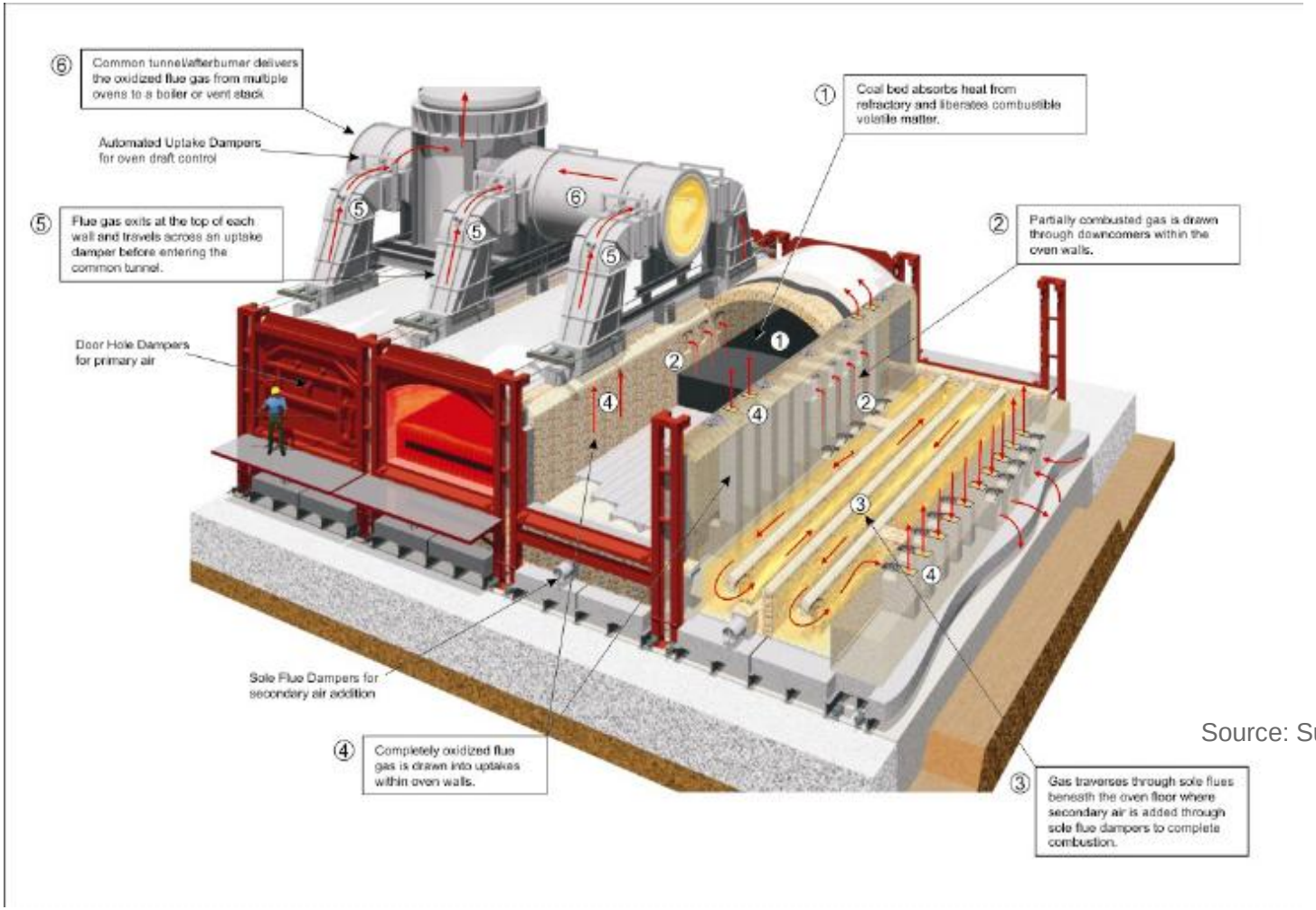
Iron Sources for Steel in the US

- Scrap is the largest source of iron units in the US. This is only possible because the US is a large importer of both steel and steel intensive goods.
- The only DRI left in the US is the Iron Dynamics operation near Fort Wayne.



Coke and the Blast Furnace

Jewell-Thompson Coke Oven



Source: Sun Coke

Nature of Coke

- Coke is the result of heating coal to high temperatures in a non-oxidizing atmosphere.
- Coking removes the volatile matter from coal and the remaining carbon and ash re-solidify into a strong, hard mass suitable for blast furnace use.
- It normally takes between 1.4 and 1.6 tons of coal to produce a ton of coke.
- There are two types of coke ovens is the US:
  - By-products oven where the volatile matter is captured to produce coal chemicals and coke oven gas
  - Heat recovery ovens where the volatile matter is burned to produce steam and electricity.
- Both types of ovens are present in Indiana.

Function Of Coke

- Coke performs 5 functions in the blast furnace process:

1. Coke partially burns to produce carbon monoxide gas that is the main reducing gas for creating metallic iron
2. Coke combustion provides most of the process energy
3. Coke dissolves in the metallic iron depressing the melting point by about 700º F.
4. Coke, having an extreme melting point, is solid everywhere in the blast furnace and provides the support for the burden.
5. Coke holds it shape and leaves void space for the gas to go up and the liquids to flow down in the furnace.

Issues Around Coke

- Historically, coke ovens have been an environmental problem. Environmental controls are a larger percentage of the cost of coke batteries than any other steel mill equipment.
- Because of changes in consumption patterns, the value of coke oven by products have fallen relative to other energy products increasing the cost of cokemaking.
- With the combination of capital and environmental costs, the US has become a major net coke importer. Typically, about 20% of total consumption is imported.
- With the dependence on imported coke, the cost of coke has fluctuated wildly in the past five years from below $120/ton to over $700/ton.

Pulverized Coal Injection

- The main response to the coke plant issues has been to reduce coke consumption by installation of Pulverized Coal Injection (PCI).
- Coal is powdered, dried and then injected into the BF with the hot blast.
- PCI can replace the first 3 functions of coke (reducing gas, heat and solution carbon). It does not supply burden support or aerodynamic structure.

•A wider range of coals can be used for PCI than coking.

•As much as 35% of coke has been replaced by PCI

•The US is only at about 15% replacement and thus has catch up potential.

Source: Siemens

Impact in Indiana

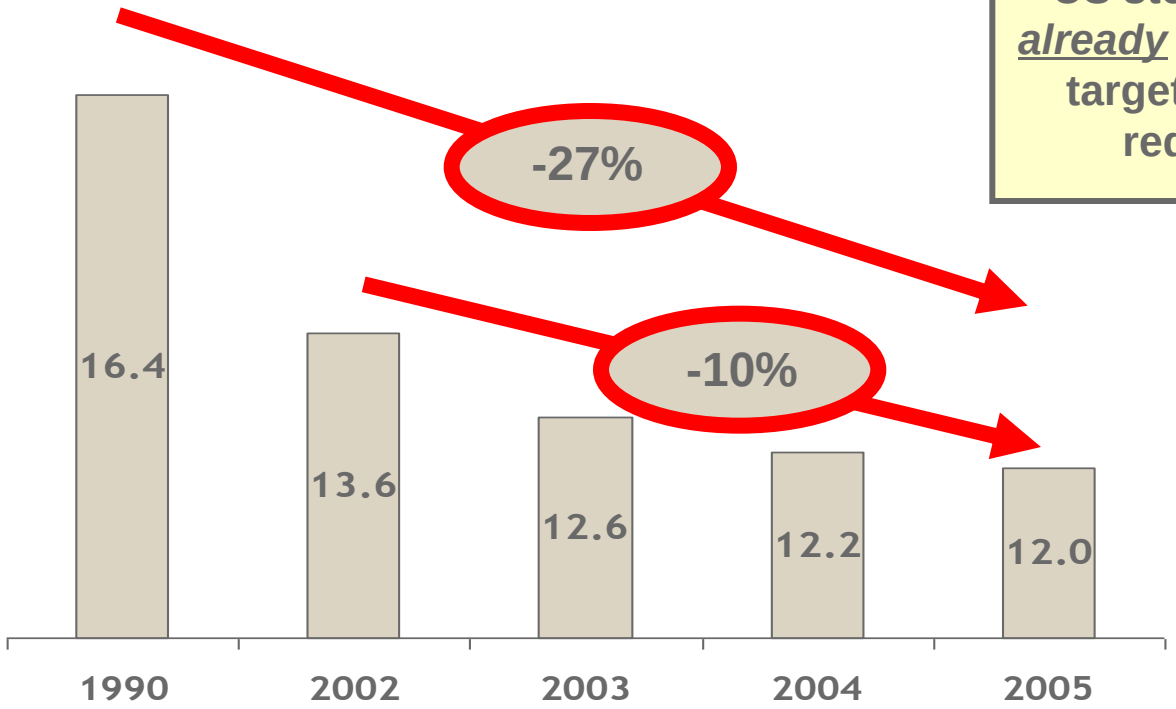
Steelmaking in Indiana

- Indiana is the largest steel producing state in the US producing about 27 million tons, 24% of the US total.
- Indiana's steel is predominantly blast furnace process.
- Out of the 36 million annual tons of pig iron made in the US, 22 million is produced in Indiana, 61%.
- Indiana is also the largest cokemaking state in the US.
- Out of 19 million annual tons of coke made in the US, 5.4 million is produced in Indiana, 28%.
- Iron Dynamics is the only DRI facility operating in the US and is one of the first coal-based DRI operations in the world.

U.S. steel industry has significantly decreased its energy intensity…

Steel Industry Composite Energy Intensity

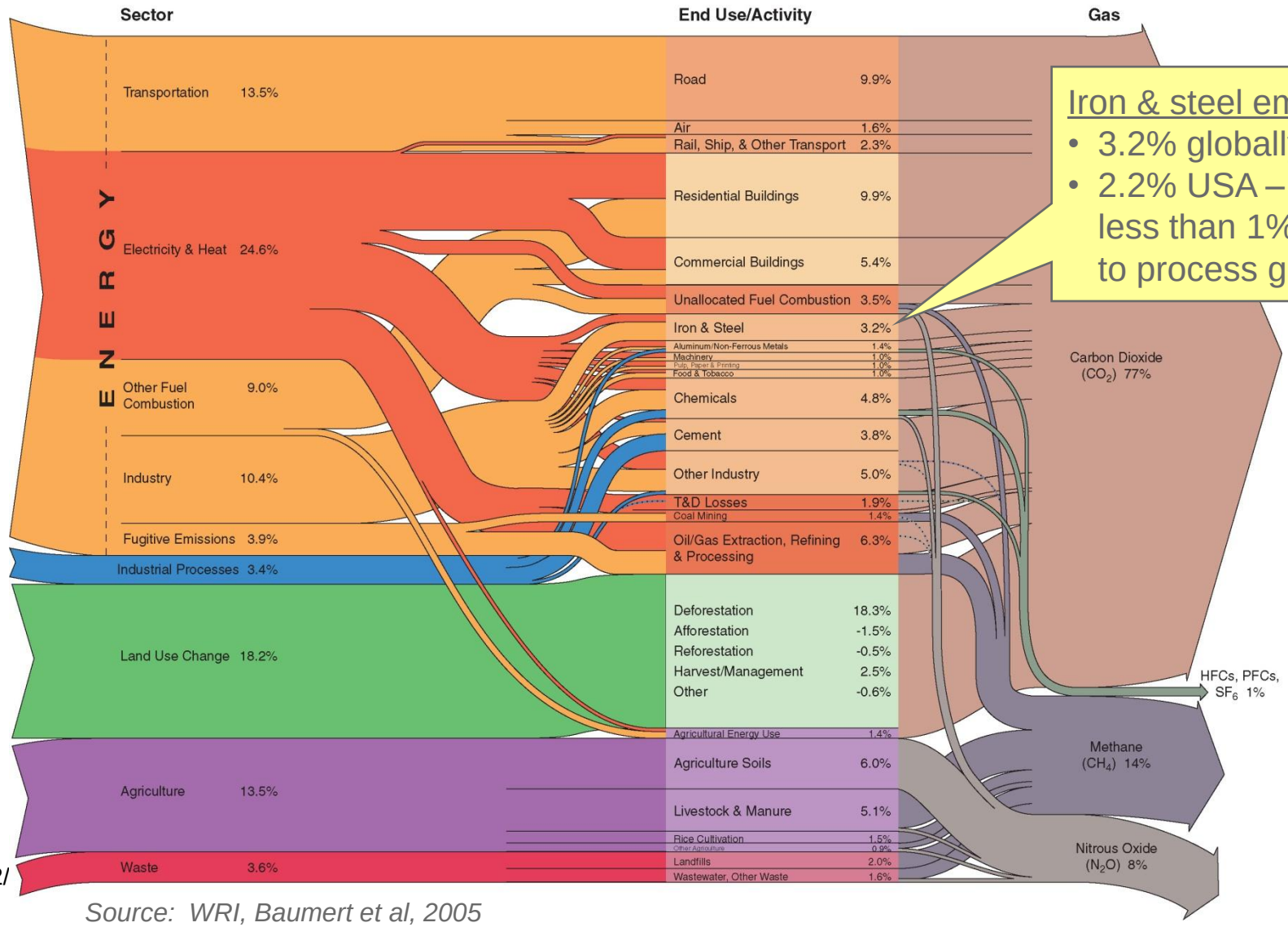
MMBTU/Ton Shipped



Through these efficiency gains the US steel industry *already* meets Kyoto targets for GHG reduction!

Source: American Iron and Steel Institute

…and globally steel accounts for ~3 percent of emissions



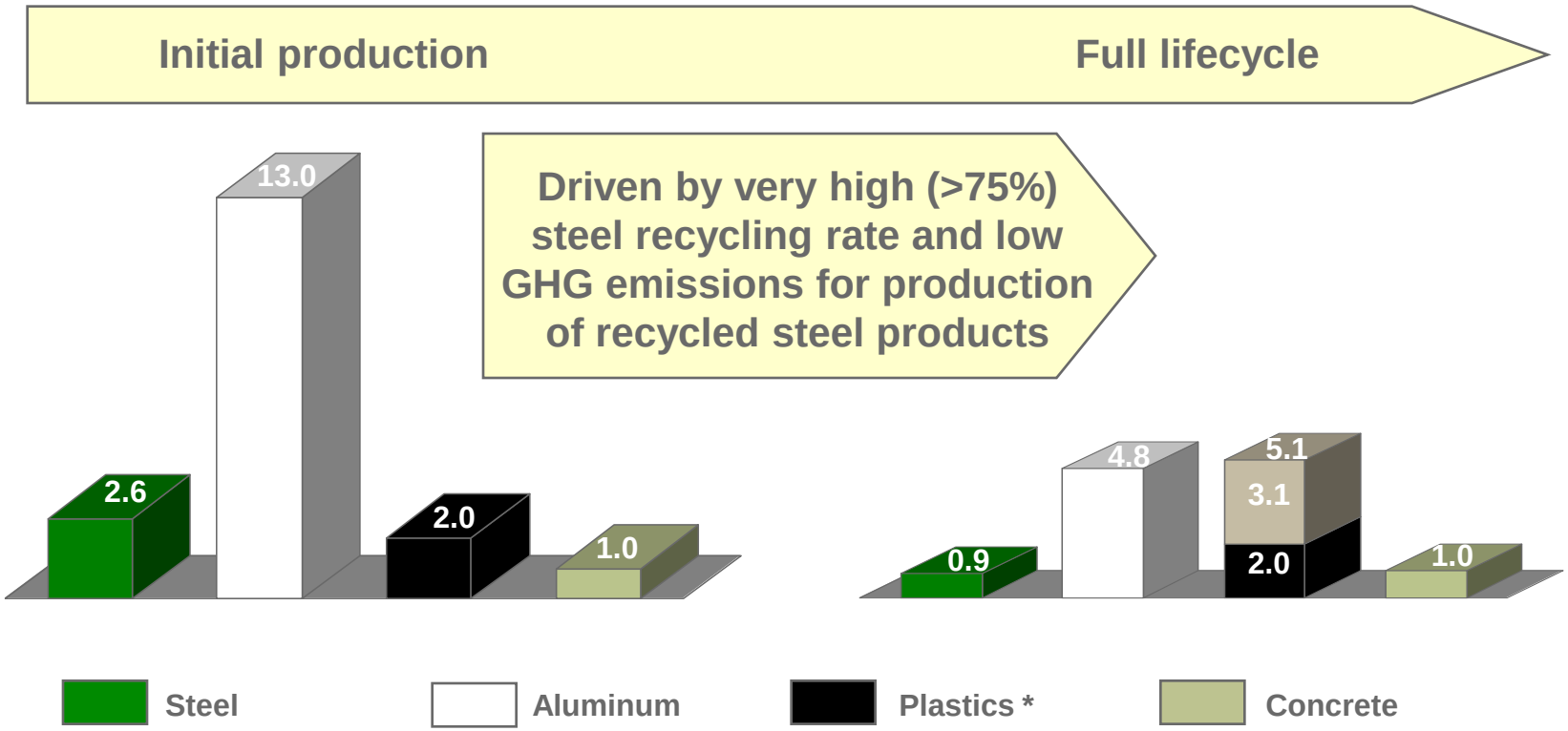
Iron & steel emissions

- 3.2% globally
- 2.2% USA – with less than 1% related to process gases

Source: WRI, Baumert et al, 2005

Steel's carbon footprint is relatively benign when evaluated on a lifecycle basis…

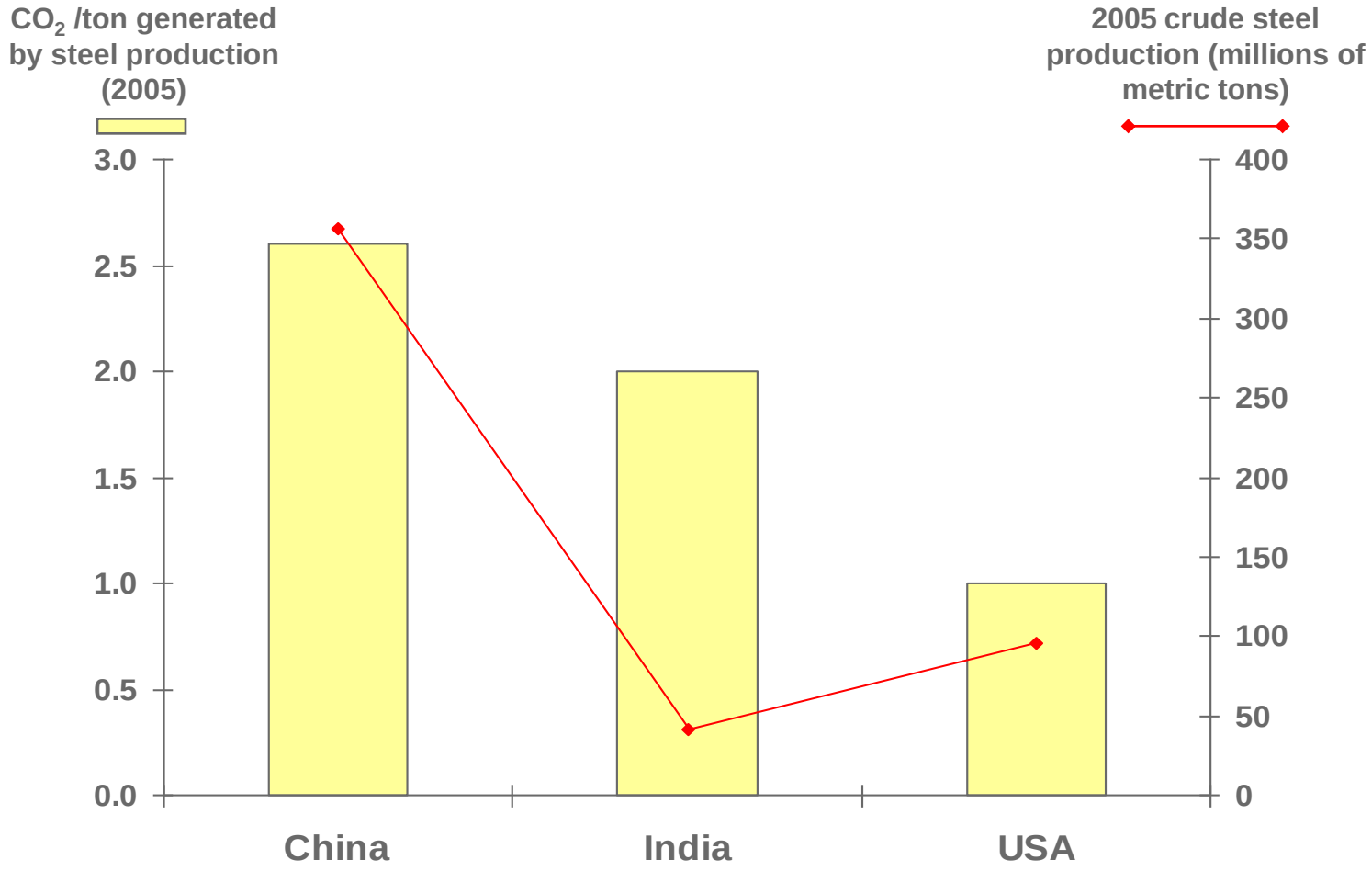
Tons CO_2 generated per ton of material



* Polypropylene; additional 3.1 tons CO2 applied for full lifecycle impact assumes combustion or eventual degradation in land fill

Source: Battelle Institute and ArcelorMittal analysis

…and much lower in developed than in developing countries…



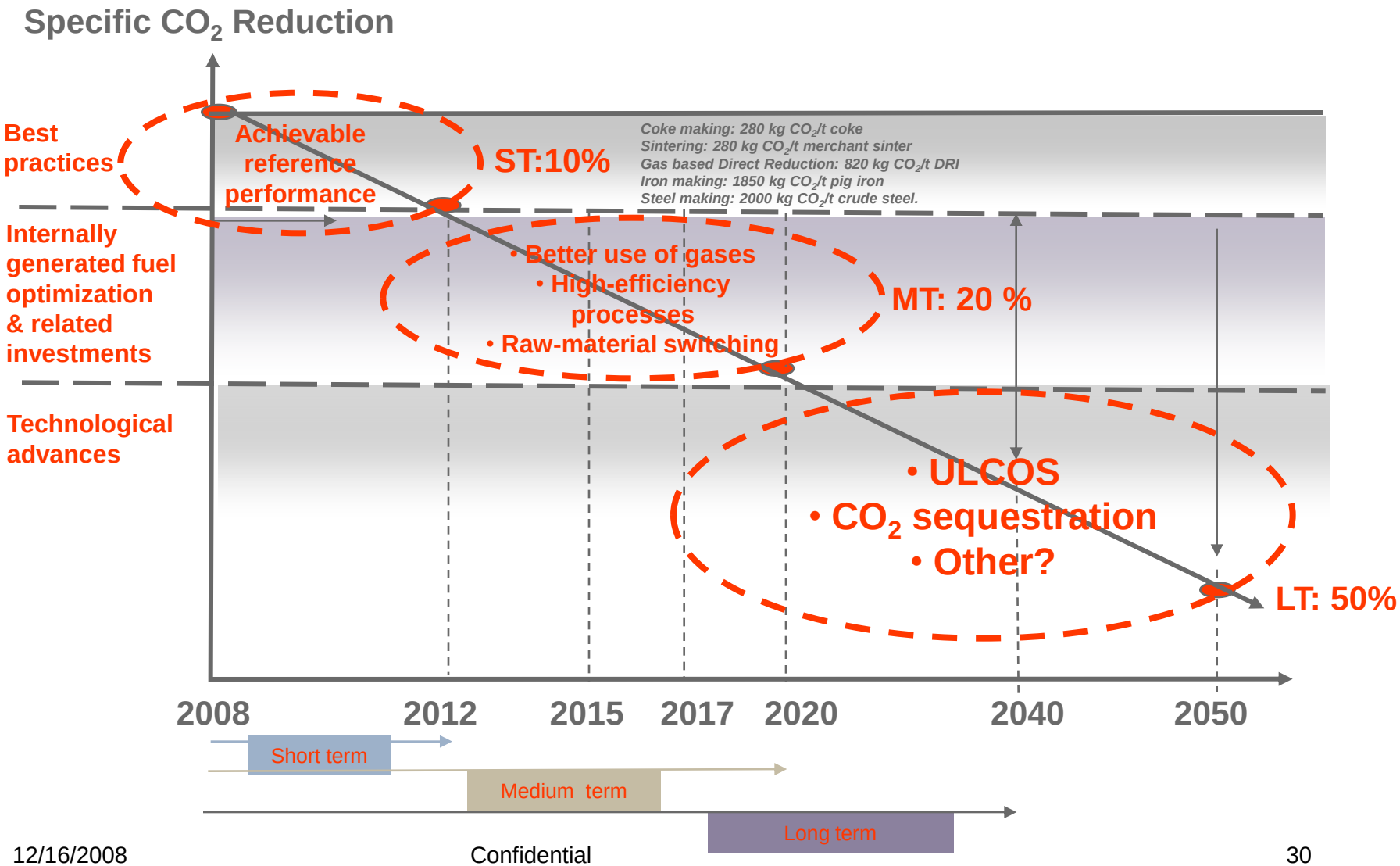
	China	India	USA
Total steel-industry CO_2 generation in 2005 (millions of tons)	925.1	81.8	94.9

Future Technology and Conclusion

Innovation is a priority…

- Improve existing technologies
  - ULCOS project – blast furnace top-gas recovery
  - AISI and Climate VISION
- Explore carbon sequestration
  - Midwest Regional Carbon Sequestration Partnership
- Investigate new concepts
  - ArcelorMittal's Clean Technology Fund - Miasolé

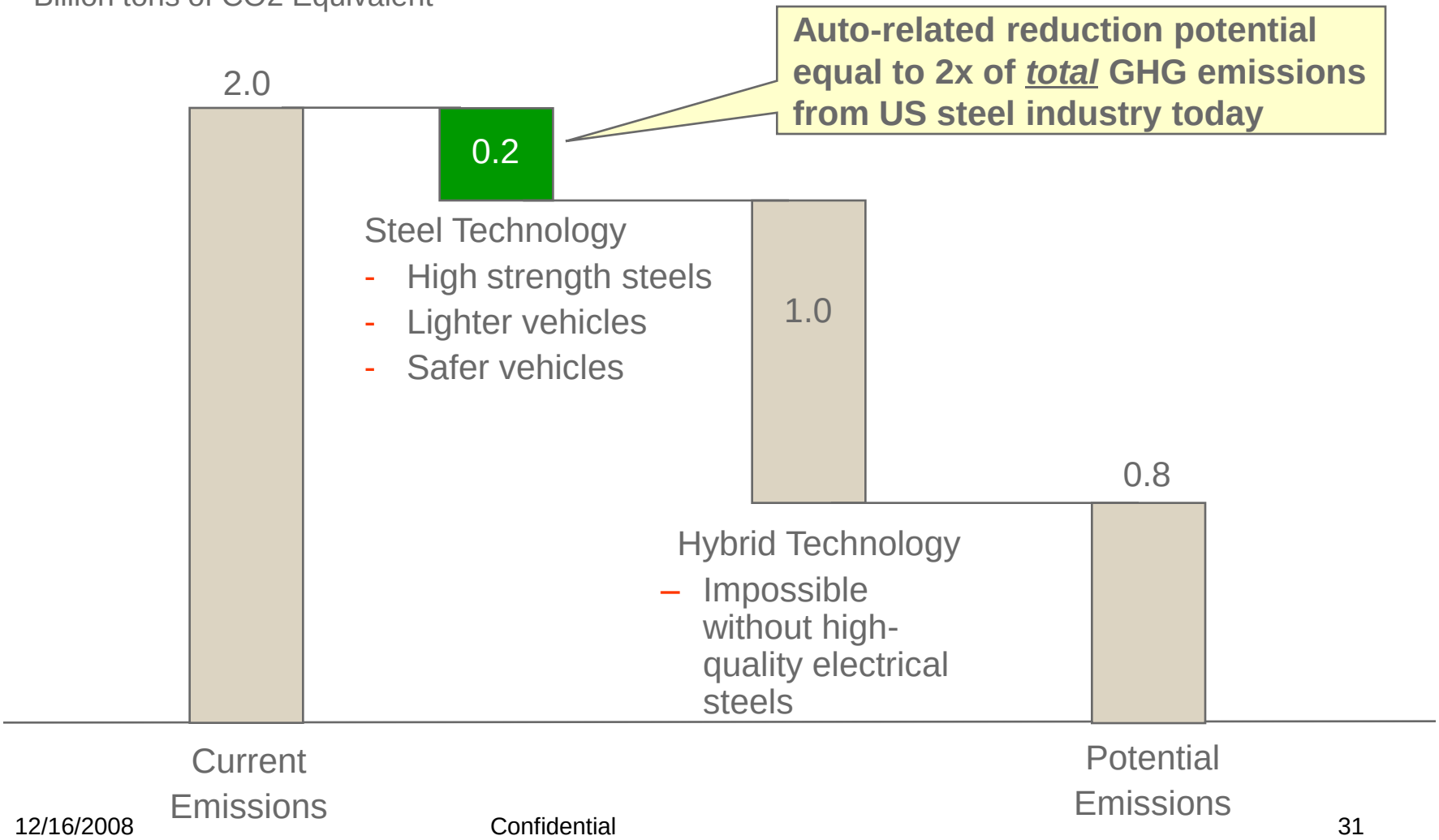
…and R&D investments must be widespread to prove effective



…the auto industry as an example

Annual USA Automotive Greenhouse Gas Emissions

Billion tons of CO2 Equivalent



Source: US Department of Energy, US Government Energy Information Administration, ArcelorMittal automotive marketing

Important issues to consider in climate change legislation…

- Cap and Trade
  - Global approach
  - Recognition of technology constraints
- Trade implications
- Comprehensive policies
- State of global economy

…must reflect steel's environmental benefits and unique challenges

ArcelorMittal

Challenge	Solution
Lack of technology to make virgin steel without carbon	Exempt fixed emissions in chemical processes in manufacturing until there is a feasible technological alternative; provide increased federal funding for technology development
Potential "carbon leakage" to countries which don't adopt similar carbon restraint programs, resulting in *less* jobs and *more* global emissions	Modify competitive provisions to insure the same mandatory rules on allocations and baselines are applied to both foreign and domestic producers; temporary additional allowances for import sensitive products; global sector agreement
Failure to measure emissions of manufactured materials such as steel on a "lifecycle" basis, thus disadvantaging products with high recycle potential	Bonus credits for products that meet stringent recycling and reuse tests, substantially reduce carbon emissions over material lifespan, and offer environmental benefits over non-recycled products

With these policy changes American steel can help lead the nation and the world into a lower carbon future