



Other Issues for Sectoral Approaches

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Topics

- Cement
- Iron & Steel
- Aluminum
- Electricity
- Identifying internationally-competitive industries

Cement

- Benchmarking & Best Practices
- Boundary Issues
- Questions to consider

Cement: Benchmarking

- Benchmarking and Energy Saving Tool (BEST) Cement for China
 - » developed by Lawrence Berkeley National Laboratory, together with Energy Research Institute, China Cement Association, China Building Materials Academy, and Shandong University
 - » a self assessment tool to be used by cement plants in benchmarking their energy use against best practice levels and evaluating the impact of selected energy efficiency measures
 - » focuses only on the energy performance aspect of cement production. It does not calculate GHG emissions
- Cement Sustainability Initiative (CSI) database
 - » Global database (less information at present for China)
 - » Energy use and emissions

Cement: Illustrative Values

Reduction of fuel energy demand

	<u>Modernization of an “old” cement plant</u>		<u>new “state of the art” cement plant</u>	
	“Old” plant	Modernized plant	New plant	
Heat cons.	1000	750	710	Kcal/kg _{cli}
CO ₂ from raw meal	0,27	0,27	0,27	Nm ³ _{CO₂} /kg _{cli}
CO ₂ from fuel	0,2	0,15	0,14	Nm ³ _{CO₂} /kg _{cli}
Total CO ₂ Emission	0,47	0,42	0,41	Nm ³ _{CO₂} /kg _{cli}

Source: Schurmann & Binniger, *CO₂ abatement possibilities in cement plants*, presented at the CSI Workshop, Washington DC, 19-May-2008.

Cement: Best Practices

World Best Practice Final Energy Intensity for Cement (GJ/tonne)

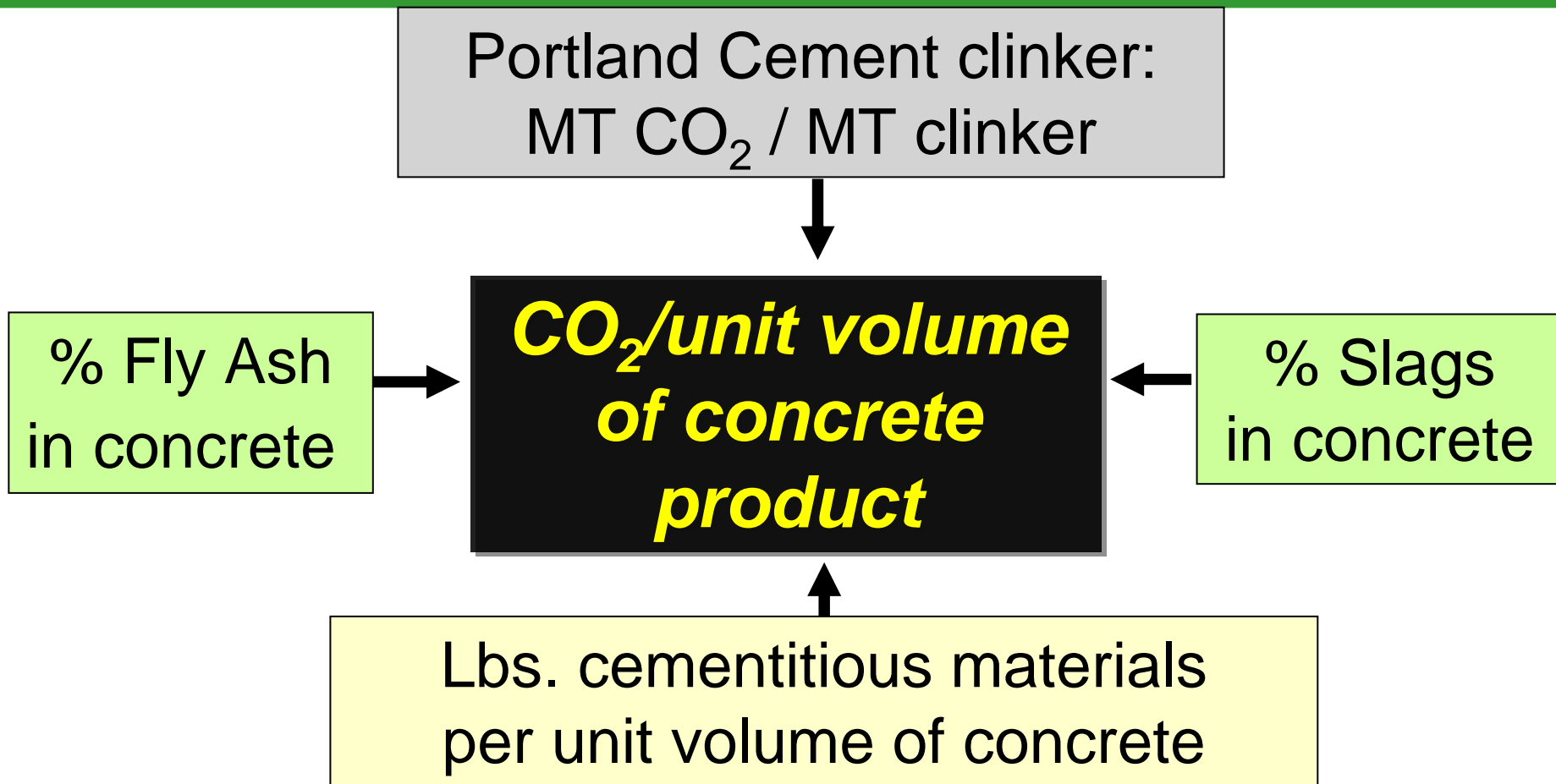
	Portland Cement 5% Additives			Cement 25% Fly Ash			Cement - 65% Blast Furnace Slag		
	Electricity	Fuel	Final Energy	Electricity	Fuel	Final Energy	Electricity	Fuel	Final Energy
Raw Materials Preparation	0.07		0.07	0.05		0.05	0.03		0.03
Solid Fuels Preparation	<.005		<.005	<.005		<.005	<.005		<.005
Clinker Making	0.08	2.71	2.79	0.05	1.90	1.95	0.03	1.00	1.03
Additives Preparation			0	0.03		0.03	0.09	0.45	0.54
Finish Grinding:325 Cement	0.06		0.06	0.08		0.08	0.15		0.15
Total: 325 Cement	0.21	2.71	2.92	0.21	1.90	2.11	0.30	1.45	1.75

Source: Worrell E., L. Price, M. Neelis, C. Galitsky and N. Zhou, (2008) *World Best Practice Energy Intensity Values for Selected Industrial Sectors*, Lawrence Berkeley National Laboratory, LBNL-62806 REV. 2, February 2008.

Boundary Issues

- Where we draw the measurement boundary, or “fence,” has important implications for sectoral agreements
 - » What we choose to measure (or not measure)
 - » Energy use vs. emissions
 - » Direct use, indirect use, & process emissions
 - » How far to go “upstream”?
 - » How far to go “downstream”?
- Poor choices for boundaries and metrics can limit the potential benefits
 - » Attractive opportunities may be overlooked
 - » Good actions may be taken but not counted
 - » Unproductive activities may be rewarded
 - » “Gaming” opportunities can undermine confidence

Concrete's CO₂ Drivers



Source: Adapted from Thomas M. Pounds, CalStar Cement, *Concrete Data: CO₂ from Cement and Concrete in the U.S., 1990 – 2050*, presented to American Coal Ash Association, 02-July-2008.

U.S. Cement & Concrete Intensity

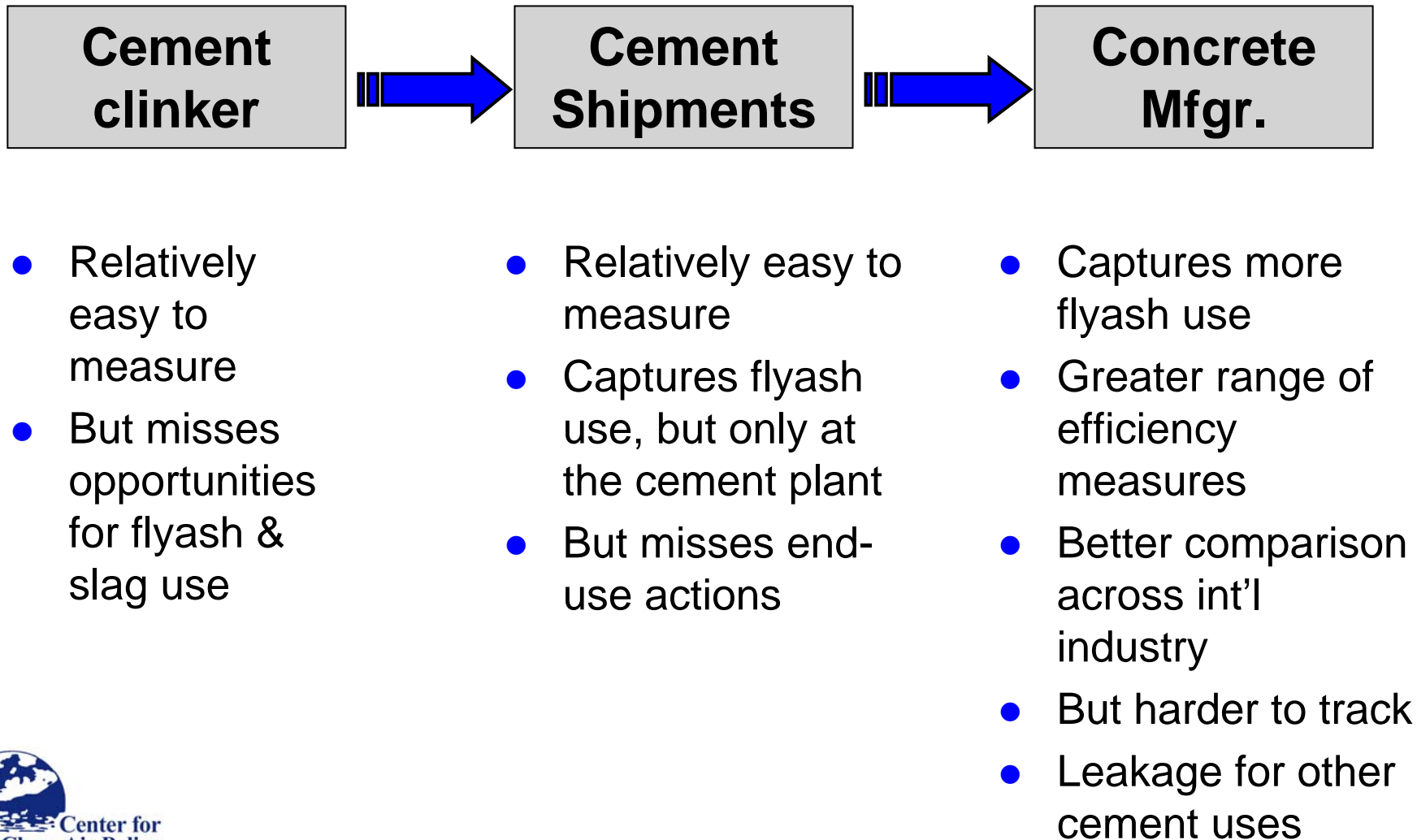
Trends: 1990 to 2005

Variable	1990	2005	% change
Portland Cement: MT CO ₂ /MT cement	0.99	0.94	-5%
% flyash & slag in concrete	4%	12%	+200%
Lbs. cementitious material per cubic yard concrete	600	550	-8%
MT CO ₂ per cubic yard concrete	.26	.21	-19%
Total MT CO ₂ output	77	115	+49%

Kiln efficiency is only a part of overall intensity improvements!

Source: Adapted from Thomas M. Pounds, CalStar Cement, *Concrete Data: CO₂ from Cement and Concrete in the U.S., 1990 – 2050*, presented to American Coal Ash Association, 02-July-2008.

Effects of Different Measurement Boundaries



Cement: Issues

- Need to distinguish by process type (wet vs. dry)?
 - » Can wet process be retrofitted to dry?
 - » Or is it easier to build new?
- Measure output as clinker, or as cement?
- How to account for blended cements
 - » Blended at the cement plants
 - » Blended in concrete manufacturing
- How to account for full-scale production sites vs. grinding & mixing operations?
- Does co-generation create another “product”?
 - » Own use
 - » Sales into the grid

Iron & Steel

- Benchmarking & Best Practices
- Multiple Processes
- Multiple Products
- Questions to consider

Iron & Steel: Benchmarking

- International Iron and Steel Institute (IISI) database
 - » IISI's climate change policy is aimed at reducing CO₂ emissions worldwide through a global steel sector approach.
 - » The core of the approach is collection & reporting of CO₂ emissions data by steel plants in all major steel producing countries.
 - » The information will lead to benchmarking improvements based on actual performance data, then reporting and setting of commitments on a national or regional basis for post-2012 implementation.
 - » Phase 1 of the global sectoral approach to climate change for the steel industry -- the design and testing of a globally consistent calculation methodology -- has been completed.
 - » As of April 2008, Phase 2, a specially commissioned secure website is now available to collect emissions data from all steel plants worldwide.

Iron & Steel: Illustrative Results

Process breakdown and energy intensities as used in BEST to benchmark iron and steel plants

Process	Fuel (GJ/ton)	Steam (GJ/ton)	Electricity (GJe/ton)	Oxygen (Nm ³ /ton)
Coke plant	1.76	0.29	0.11	0
Sinter plant	1.43	-0.16	0.11	0
Pellet plant	0.66	0.00	0.14	0
Blast Furnace	11.53	0.40	0.09	35
Basic Oxygen Furnace	0.09	-0.15	0.09	52
Electric Arc Furnace	0.54	0.00	1.47	37
Refining	0.00	0.00	0.13	0
Casting – slab	0.03	0.00	0.03	0
Casting – billet	0.03	0.00	0.03	0
Hot rolling – plate	1.08	0.00	0.29	0
Hot rolling – strip	1.25	0.02	0.28	0
Hot rolling - bar	1.50	0.00	0.25	0
Hot rolling – wire	1.60	0.00	0.38	0
Cold rolling	0.05	0.09	0.26	0
Finishing	0.73	0.26	0.13	0

Source: IISI, 1998, reported in Worrell and Price, 2006

Measurement Issues: Multiple Processes

- Often, a product can be produced using more than one technology
 - » Electricity: coal vs. natural gas vs. nuclear
 - » Coal-fueled electricity: supercritical, USC, IGCC
 - » Cement clinker: wet vs. dry process
 - » Steel: BOF vs. electric arc furnace
- Plant operators sometimes have choices. Sometimes not. Sectoral approaches should aim to:
 - » Reward the choice of "right" options when choices are possible
 - » Not penalize "poorer" options when there aren't really better ones
- Issue: Where to measure for sectoral programs?
 - » Measuring at end product doesn't relate well to specific processes
 - » Measuring at specific processes may discourage shifts to more efficient technologies

Measurement Issues: Multiple Products

- Many products are commodities, traded using standards specifications
- Where single-product outputs are typical, metrics are easier to identify
 - » Btu per kWh
 - » Btu per ton of clinker
- But many industries produce multiple products, making the output metrics more complicated
 - » Forest products
 - » Petrochemicals
 - » Output mix varies widely from plant to plant
 - » What is the denominator? The benchmark?

Iron & Steel: Issues

- BOF vs. electric arc furnaces
 - » Separate benchmarks?
 - » How to handle Direct Reduced Iron (DRI)?
 - » How to encourage more scrap use?
- Product outputs
 - » How to account for multiple products?
 - » How to account for changing product mix?
- Variations in industry structure
 - » How to account for activities when degree of vertical integration differs?
 - » How to account for upstream activities?
 - » How to account for dedicated infrastructure?

Aluminum

- Benchmarking & Best Practices
- Indirect emissions
- Recycling vs. primary production
- Questions to consider

Aluminum: Benchmarking

- Aluminium for Future Generations Sustainable Development Programme
 - » launched in 2003, currently comprises 13 voluntary objectives and 22 performance indicators
 - » An IAI team of technical experts provides advice and training on good practice around the world.
- International Aluminium Association (IAI) statistics & reporting on voluntary objectives
 - » IAI collects energy use and PFC emissions data
 - » using the IAI/GHG Protocol measurement protocol and tool

Aluminum: Illustrative Results

World Averages: Energy Inputs for 1000 kg in Primary Aluminium Production

Process	Bauxite Mining	Alumina Production	Anode Production	Electrolysis	Casthouse	Total	Units
Fuels and electricity							
Coal		170	1,0		1,2	173	kg
Diesel Oil	6,0	1,3	1,0		1,4	9,7	kg
Heavy Oil	1,3	195	4,9		5,7	207	kg
Natural Gas	0,002	223	23		30	277	m ³
Electricity	10	242	56	15289	83	15680	kWh

Source: IAI, *Life Cycle Assessment of Aluminium: Inventory Data for the Primary Aluminium Industry*, Year 2005 Update, September 2007

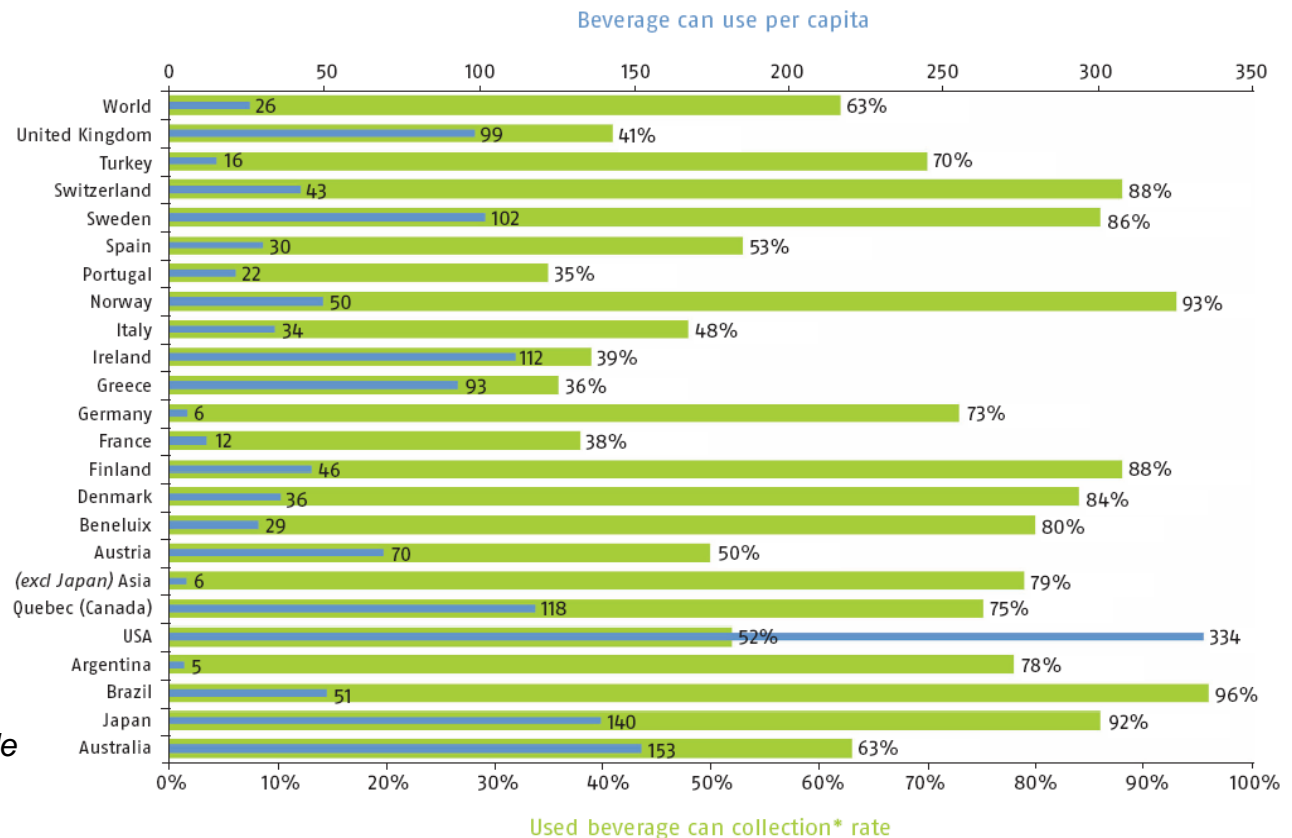
Measuring indirect emissions

- Electricity is biggest energy input and source of emissions
- How to assign GHG emissions to electricity use?
 - » Exclude altogether?
 - » Specific source?
 - » System factor?
 - » National or regional factor?
 - » And for all, average vs. marginal?
- Would incentives change behavior, or just shift activities?
- Possible guiding principle:
 - » Producers can control how much power used, but not it's generation
 - » Generators can control how they GHG mix, but not usage

Aluminum Recycling

- Recycling aluminum is far less GHG-intensive than primary production
- But resource availability varies widely
- Where we place the sector “fence” has implications and incentives

Source: IAI, *Global Aluminium Recycling: A Cornerstone of Sustainable Development*, 2006



Aluminum: Issues

- How to measure indirect emissions from electricity use?
 - » Focus on kWh?
 - » or GHGs?
 - » If indirect GHGs, how to measure?
- Quality and accuracy of PFC emission measurement
- Other direct and process emissions
- Where to draw the “fence”
 - » Primary production only?
 - » Primary + recycled production?

Electricity

- Benchmarking & Best Practices
- Leakage in world fuel markets
- Effects of life-cycle analysis (LCA)
- Questions to consider

Electricity: Benchmarking

- Asia-Pacific Partnership on Clean Development & Climate
 - » Power sector task forces:
 - Cleaner Fossil Energy
 - Power Generation & Transmission
 - Renewable Energy & Distributed Generation
 - » Activities under way:
 - Sharing Best Practices in Cleaner Fossil Energy
 - Comparison of Power Efficiency on Grid Level
(Benchmarking Energy Efficiency)
 - Best Practices in Indian Thermal Power Generation Units

Electricity: Illustrative Values

Cost and Performance Characteristics of New Central Station Electricity Generating Technologies

Technology	Online Year ¹	Size (mW)	Heatrate ⁶ in 2007 (Btu/kWhr)	Heatrate nth-of-a-kind (Btu/kWhr)
Scrubbed Coal New ⁷	2011	600	9,200	8,740
Integrated Coal-Gasification Combined Cycle (IGCC) ⁷	2011	550	8,765	7,450
IGCC with Carbon Sequestration	2011	380	10,781	8,307
Conv Gas/Oil Comb Cycle	2010	250	7,196	6,800
Adv Gas/Oil Comb Cycle (CC)	2010	400	6,752	6,333
ADV CC with Carbon Sequestration	2010	400	8,613	7,493
Conv Combustion Turbine ⁸	2009	160	10,833	10,450
Adv Combustion Turbine	2009	230	9,289	8,550
Fuel Cells	2010	10	7,930	6,960

Source: U.S. Dept. of Energy, Energy Information Administration, *Assumptions to the Annual Energy Outlook 2008*, Table 38, page 79, February 2009.

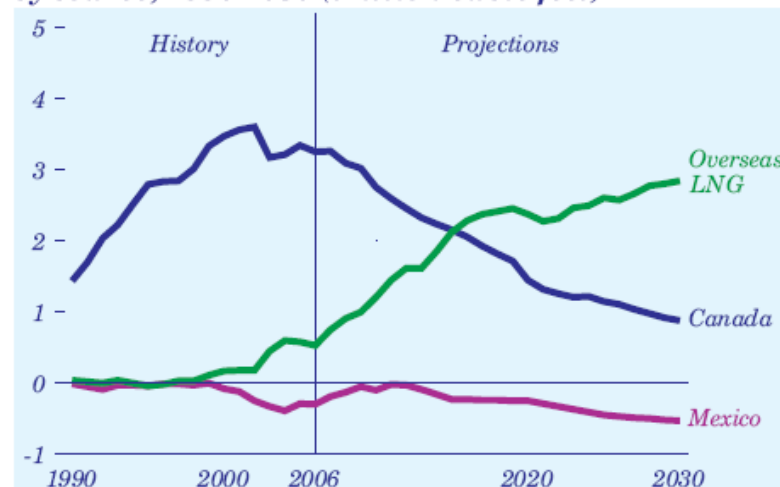
“Leakage” in world fuel markets?

- Different levels of competition for energy supplies
 - Coal mostly regional
 - Petroleum global
 - Natural gas regional, moving towards global
 - Renewables mostly regional & local

- LNG market growth will move natural gas to global trade

(source: EIA, *Annual Energy Outlook 2008*,
<http://www.eia.doe.gov/oiaf/aeo/gas.html>)

Figure 82. Net U.S. imports of natural gas by source, 1990-2030 (trillion cubic feet)



Fuel shifting can affect *net* GHG

- Question: Does a shift in demand get matched by similar supply increases?
 - » Or, do fuel markets shift?
- If, for example, China was to shift some coal to natural gas firing:
 - » Some global increase in natural gas production?
 - » Or, higher prices encourage more conservation?
 - » Or, might some gas users shift to coal?
- Net global GHG emissions may be higher or lower than changes at the end-user might suggest

Life-Cycle accounting for fuel shifting?

- Natural gas has a clear GHG advantage at the burner tip
- But upstream emissions can narrow the savings:
 - » Higher upstream footprint for gas than for coal
 - » Higher still for LNG

Life-cycle GHG Emission Factors (units: lbs/MMBtu of Fuel Produced)

Life-cycle Stages	North American NG		LNG		Coal	
	Min	Max	Min	Max	Min	Max
Upstream	15.3	20.1	29.6	72.3	8.2	16.4
Combustion (no CCS)	120	120	120	120	205	205

Source: Jaramillo et al., CMU, *Comparative Life-cycle Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electricity Generation* (supporting information), 2007.

- Question: Can sectoral accounting create unhealthy incentives?

Electricity: Issues

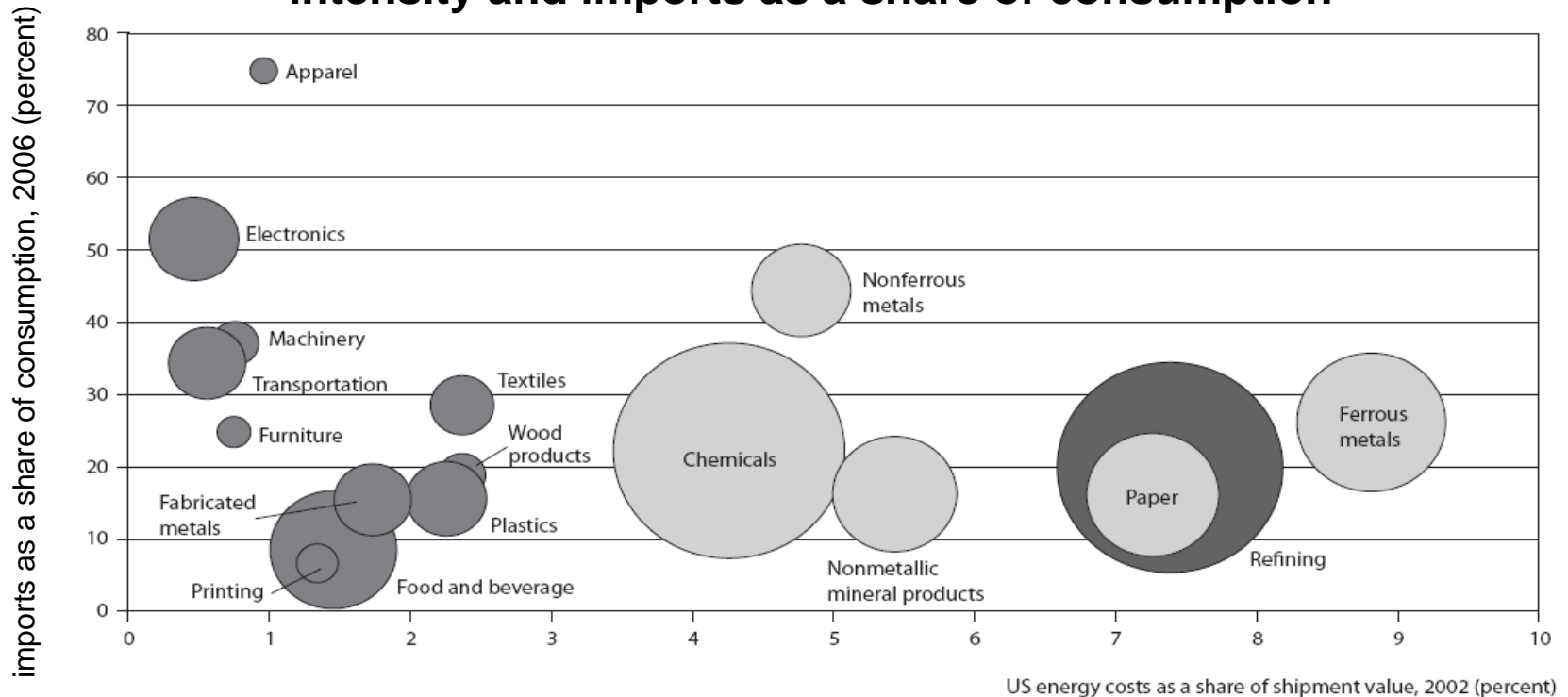
- Distinguish by fuel type?
 - » Coal (further categorized by coal rank?)
 - » Natural gas
 - » Nuclear & renewables
- Distinguish by equipment type?
 - » Supercritical
 - » USC
 - » IGCC
- Does plant-by-plant vs. system-wide measurement change incentives for fuel switching & new builds?
- Does fuel switching have “leakage” effects?

Identifying “At-Risk” Industries

- Some measures of competitiveness and risk
- Questions to consider

Limited number of International Competitive industries at risk

US industry exposure to climate costs based on energy intensity and imports as a share of consumption



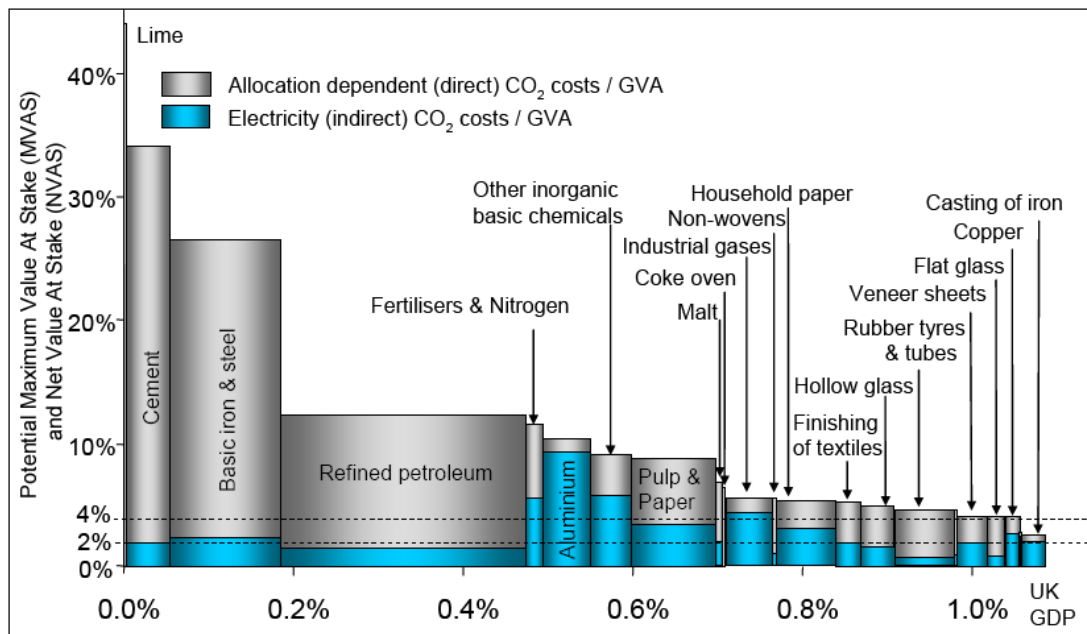
Note: The size of the bubbles indicates the total CO₂ emissions from the industry in 2002.

Sources: US Department of Commerce, Bureau of Economic Analysis, Industry Economic Accounts, 2007; US Department of Energy, Energy Information Administration, Manufacturing Energy Consumption Survey 2002.

Source: Peterson Institute for International Economics and World Resources Institute, *Leveling the Carbon Playing Field: International Competition and US Climate Policy Design*, May 2008

Limited number of International Competitive industries at risk

Subsectors potentially exposed under unilateral CO₂ pricing



- Addressing carbon differences within Annex I and between developing countries and Annex I may not eliminate job and plant shifts
 - » because of differences on taxes and labor costs etc
 - » but can reduce the impact of carbon regulation on those shifts
- Once these sectors are addressed, it will be easier for Annex I countries to set aggressive national reduction targets

Source: Climate Strategies (Hourcade, Demailly, Neuhoff and Sato), *Differentiation and Dynamics of EU ETS Industrial Competitiveness Impacts*

Competitiveness: Issues

- Measures to focus on?
 - » GHG per unit output?
 - » Energy use per unit?
 - » % of sales revenue?
 - » \$ of GVA?
- Minimum threshold for consideration?
 - » Set a *de minimis* floor?
 - » Compare to currency rate fluctuations?
- Where to draw the “fence”?
 - » Sector, or sub-sector?
 - » Unintended consequences among sectors?