



# Benchmarking, Boundary, and Measurement Issues for Sectoral Approaches

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# Going from Theory to “Proof of Concept”

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- A number of benchmarking, measurement, & boundary issues in each sector
  - » Differences among industries
  - » Variations within each industry
- These issues are especially important when incentives are introduced
  - » Before, measurements had fewer consequences
  - » After, measurements have financial implications
  - » *What* you measure, and *how* you measure, affects how rewards/penalties are distributed
  - » Resolution of measurement and boundary issues reflects policy and preferences
  - » Let the end goals drive the process. Start with the end in mind

# Industry Suitability to Sectoral Approaches

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- This workshop will explore some of these issues specific to each industry
  - » “Proof of Concept” is the goal
  - » What does – or doesn’t – work for a particular sector?
  - » Possibly, some industries might not be well-suited for sectoral approaches
- Some characteristics suitable for sectoral approaches
  - » Energy use and emissions large enough to warrant the effort
  - » Relatively uniform product
  - » Limited number of co-products
  - » Production processes that can be compared
  - » Abilities to measure, report & verify data

# “One size fits all” may not apply to sectoral approaches

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- Different characteristics may favor (or disfavor) different sectoral approaches
  - » Variations within industries
  - » Variations across different industries
- Variations in production capacity
  - » Age of plants
  - » Types of processes
- Importance of raw material supply & geology
  - » Fuels: coal, natural gas, hydro
  - » Quality of fuels and raw materials
  - » Water availability
- Local effects
  - » Transportation and transmission infrastructure
  - » Local climate & terrain
  - » Local markets for products and co-products

# Benchmarking

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- Benchmarking is composed of two main elements:
  1. measurement protocols (*how & what to measure*)
  2. performance indicators and standards (*how to use the measures*)
- Benchmarking used in two primary ways:
  1. non-incentivized comparisons (passive)
  2. incentivized (rewards/penalties) systems (active)
- Primary goal for this study is the enumeration of performance indicators and standards.
  - » However, much more work has been done on measurement protocols than on performance metrics.
  - » In using existing industry efforts, we need to recognize limits in the scope of performance indicators and standards that can be developed.

# Performance Indicators & Standards

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- Goal: identifying & closing the “gap” between current efficiency and what could be achieved
- But these differences can reflect many things:
  - » Inefficiencies & opportunities for improvements
  - » Differences in process inputs
  - » Differences in product output mix

} *often beyond a plant's control*

*The Challenge: How to tell which is which?*

- How to find the “right level” for benchmarks?
  - » Not too detailed for industry-wide agreements
  - » Not too simplified for plant-level operations

# Measurement & Boundary Issues

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- Where do you place the “fence”?
- Multiple processes for making the product
- Multiple products from a facility
- How to account for indirect GHG emissions
- Downstream opportunities for energy & GHG savings

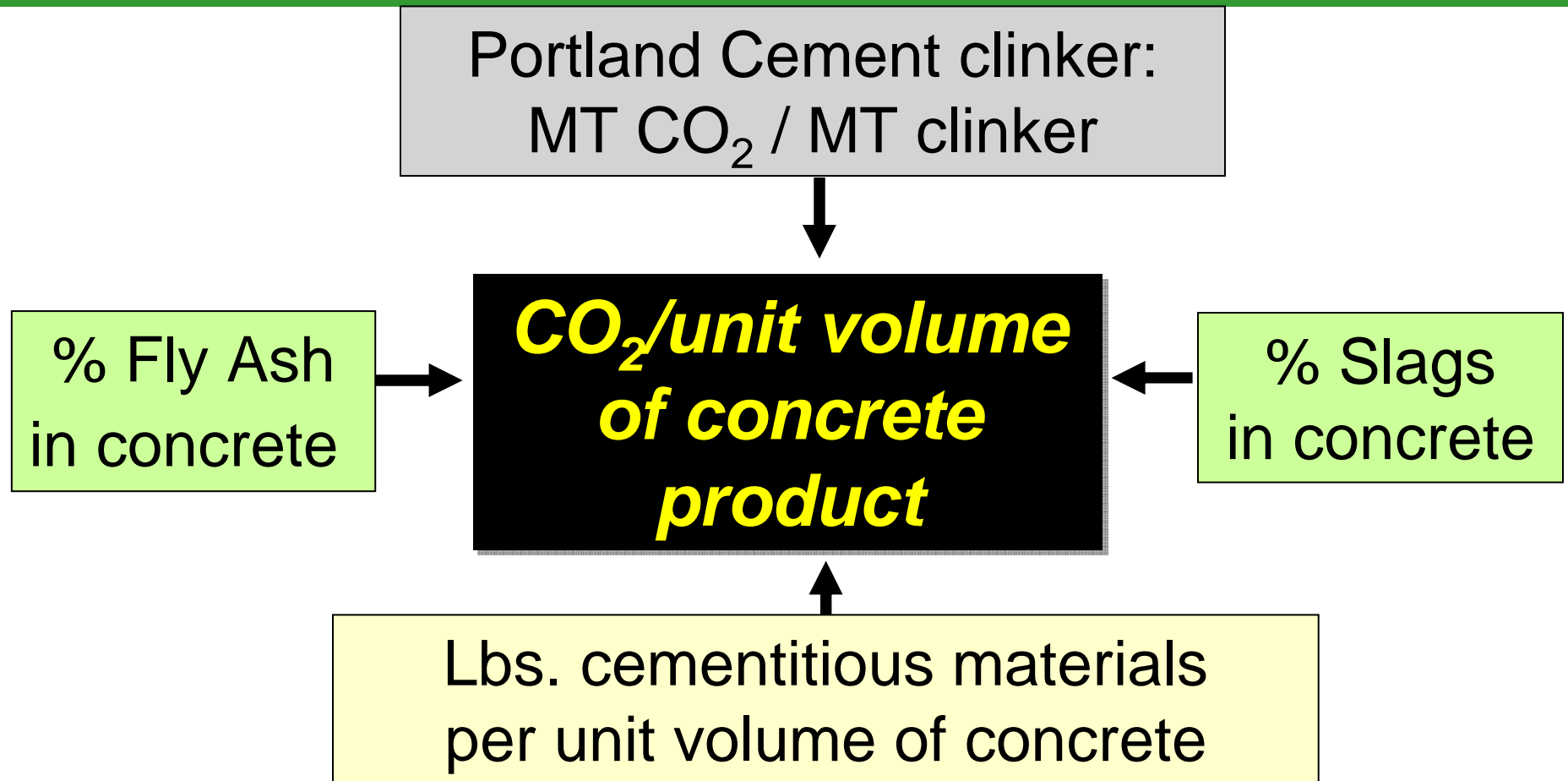
# Boundary Issues

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- 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 CO<sub>2</sub> Drivers



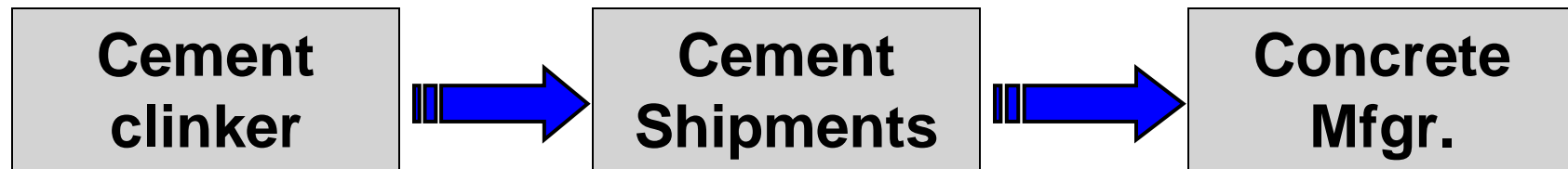
# U.S. Cement & Concrete Intensity

## Trends: 1990 to 2005

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

***Kiln efficiency is only a part of overall intensity improvements!***

# Effects of Different Measurement Boundaries



- Relatively easy to measure
- But misses opportunities for flyash & slag use

- Relatively easy to measure
- Captures flyash use, but only at the cement plant
- But misses end-use actions

- Captures more flyash use
- Greater range of efficiency measures
- Better comparison across int'l industry
- But harder to track
- Leakage for other cement uses

# Measurement Issues: Multiple Processes

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- 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

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- 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?

# Measurement Issues: Indirect Emissions

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- Electricity & steam use is a large part of many industrial processes
- How to account for these indirect GHG emissions?
  - » Do not include?
  - » Include, and use a local supplier GHG factor?
  - » Include, but use a broader regional or world factor?
- Need to distinguish, and give incentive to:
  - » Factors under the consumer's control
  - » vs. what is not under consumer's control

# Measurement Issues: Downstream

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- Performance often measured on intermediate products
- But opportunities for energy & GHG savings often come later
- Example: flyash & slag use in blended cements
  - » Many cement makers blend these materials, saving energy and GHGs from clinker production
  - » In the U.S., this is typically done at the *concrete* plant
- Point of measurement has important implications
  - » Intensity of clinker production
  - » Intensity of cement production
  - » Intensity of concrete manufacturing

# Appendix: Sector-Specific Slides and Questions

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- Cement
- Electricity
- Iron & Steel
- Petroleum
- Aluminum

# Cement: Benchmarking

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- 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 <sub>cli</sub> .
CO <sub>2</sub> from raw meal	0,27	0,27	0,27	Nm <sup>3</sup> <sub>CO2</sub> /kg <sub>cli</sub> .
CO <sub>2</sub> from fuel	0,2	0,15	0,14	Nm <sup>3</sup> <sub>CO2</sub> /kg <sub>cli</sub>
Total CO <sub>2</sub> Emission	0,47	0,42	0,41	Nm <sup>3</sup> <sub>CO2</sub> /kg <sub>cli</sub>

**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
<b>Total: 325 Cement</b>	<b>0.21</b>	<b>2.71</b>	<b>2.92</b>	<b>0.21</b>	<b>1.90</b>	<b>2.11</b>	<b>0.30</b>	<b>1.45</b>	<b>1.75</b>

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.

**Slide 19**

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FYI This figures should be entirely consistent with those produced by the BEST-Cement tool

John Newman, 8/30/2008

# Cement: Issues

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- 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”?

# Electricity: Benchmarking

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- 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 <sup>1</sup>	Size (mW)	Heatrate <sup>6</sup> in 2007 (Btu/kWhr)	Heatrate nth-of-a-kind (Btu/kWhr)
Scrubbed Coal New <sup>7</sup>	2011	600	9,200	8,740
Integrated Coal-Gasification Combined Cycle (IGCC) <sup>7</sup>	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 <sup>8</sup>	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.

# Electricity: Issues

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- Distinguish by fuel type?
  - » Coal (further categorized by coal rank?)
  - » Natural gas
  - » Nuclear & renewables
- Distinguish by equipment type?
  - » Supercritical
  - » USC
  - » IGCC
- Does the point of measurement change incentives for fuel switching?
- Does fuel switching have “leakage” effects?

# Oil: Issues

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- How far upstream do you place the “fence”?
  - » Refineries only?
  - » Production facilities?
- How far downstream?
  - » Product pipelines?
  - » Storage and transfer facilities?
- Changes in feedstocks over time
- Changes in product mix

# Iron & Steel: Benchmarking

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- International Iron and Steel Institute (IISI) database
  - » IISI's climate change policy is aimed at reducing CO<sub>2</sub> emissions worldwide through a global steel sector approach.
  - » The core of the approach is collection & reporting of CO<sub>2</sub> 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 <sup>3</sup> /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

# Iron & Steel: Issues

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- 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

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- 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
<b>Fuels and electricity</b>							
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 <sup>3</sup>
Electricity	10	242	56	15289	83	15680	kWh

# Aluminum: Issues

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- How to measure indirect emissions from electricity use?
  - » Specific contract or local supply?
  - » Regional or national averages?
  - » Global averages?
- Quality and accuracy of PFC emission measurement
- Other direct and process emissions