Private Sector Responses to Technology Policy

Gaëlle Monteiller, Senior Vice President,
Public Affairs & Environment

Our position: There are shared responsibilities for technology development

- Public policies : framework programmes on technologies that could impact all sectors and most of the end-users
  - Energy supply : nuclear, renewables,…
  - Clean coal and carbon sequestration

- Private responsibilities : focus on specific sectorial issues
  - New processes
  - Alternative cements

- Public – private partnerships :
  - Positive energy building
  - Carbon capture

LAFARGE'S RESPONSE TO THE CHALLENGE OF CLIMATE CHANGE

Ellis Gartner and Gunther Walenta
LAFARGE CENTRAL RESEARCH

CO_2 emissions :

a strong commitment

“Sustainable development consists of satisfying our short-term demands without compromising the future of our business or that of future generations.”

Bertrand Collomb – Lafarge Sustainability Report, 2002

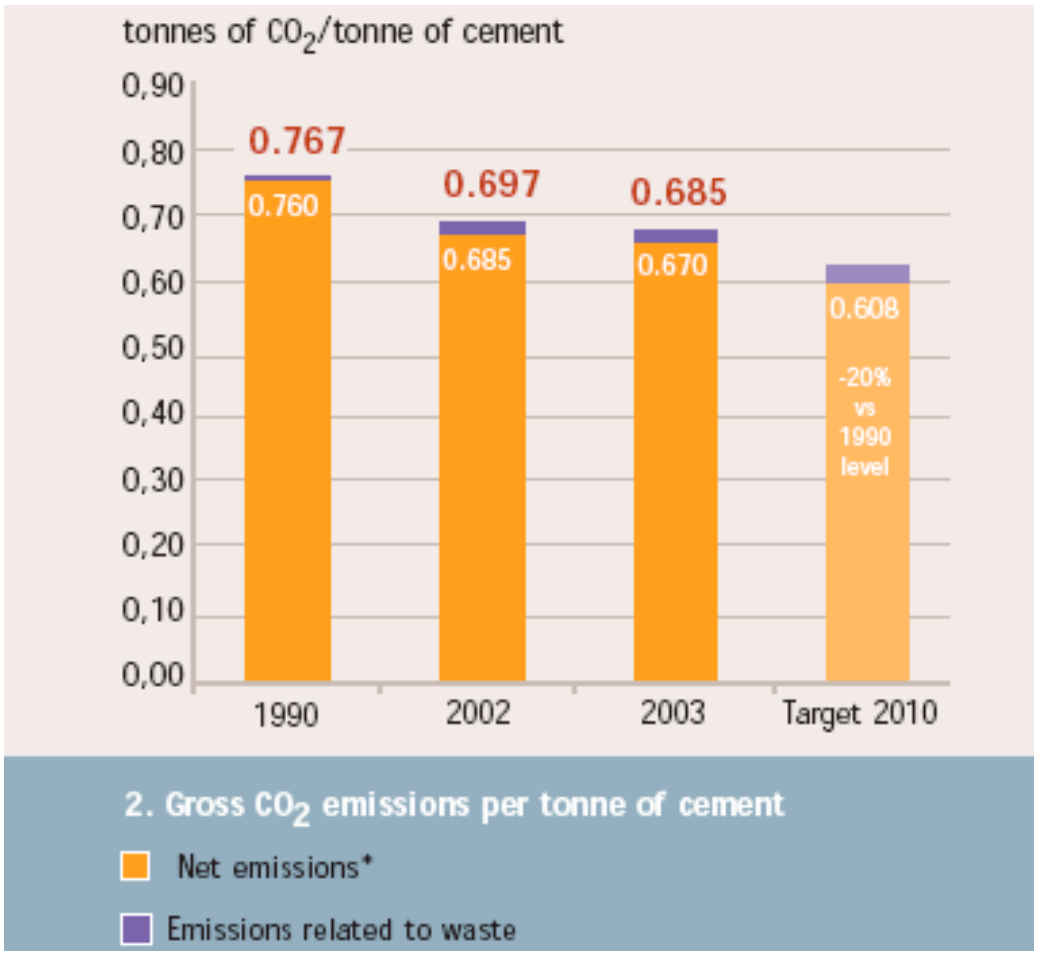
Lafarge's Position on CO_2 Emissions

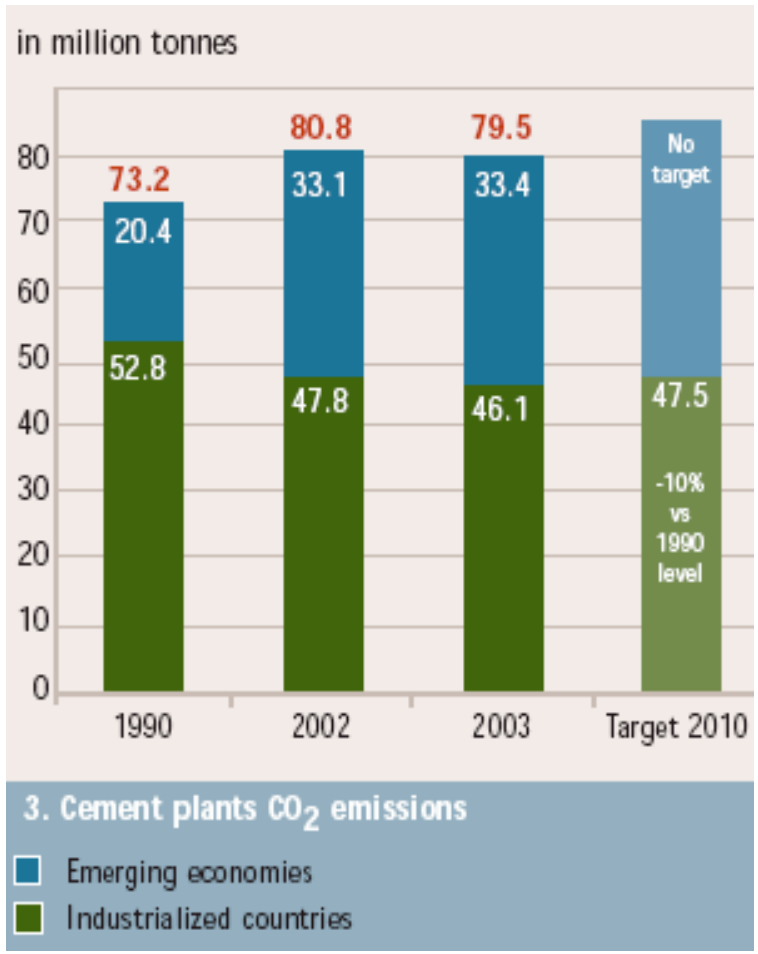
- Over 90% of the Group's CO_2 emissions come from cement plants, primarily from the burning of fossil fuels and the thermal decarbonation of limestone in cement kilns.

- In 2001, in partnership with the WWF, we set the following objectives for reducing our CO_2 emissions (from 1990 to 2010):
  - **Global average CO_2 emitted per mass of cement : -20%**
  - **Total CO_2 emitted in Industrialized Countries : -10%**

    Note: This represents a 15% total CO_2 emissions reduction if we can treat industrial by-products as zero-emissions sources.

We are well on our way to meeting our goals:





Factors Specific to the Cement Industry

- Cement is one of the least expensive manufactured materials
  - Capital costs of new manufacturing plant are relatively high, so many old plants with relatively low energy-efficiency are still in operation.
  - Cement kilns can burn a very wide variety of fuels and combustible wastes.
- Cement is only an intermediate: the final product is concrete
  - Concrete is made from cement, water and aggregates (sand, stone).
  - Very low cost/mass means that most raw materials are supplied locally.
  - Concrete is very low-CO_2 ($\approx$0.08 t/t) compared to most construction materials.
- Construction codes and standards are very conservative
  - New cement products are slow to be accepted.
  - It is much easier to regulate cement manufacture than concrete manufacture.
  - However, it is the quality control during concrete manufacture that most influences the performance of the final product. Many different additives can be used in concrete, and the cement maker has little direct influence on this.

Portland Cement Manufacturing

Working face

Shovel

Dumper

Rock

Crusher

QUARRY

PROPORTIONING AND BLENDING

CO_2

Conveyor belt

Raw Mill

Pre-heater

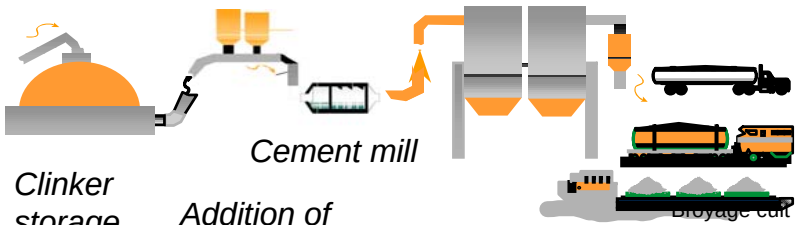
Fuel

Clinker

Rotary Kiln

CLINKER PRODUCTION

CEMENT GRINDING, BLENDING AND STORAGE



Clinker storage

Cement mill

Addition of gypsum and secondary constituents: slag, fly ash, or pozzolans

Cement silos

PACKAGING AND SHIPPING

Limestone ($CaCO_3$)

$\Rightarrow CaO + CO_2\Uparrow$

at T ≅ 900 °C

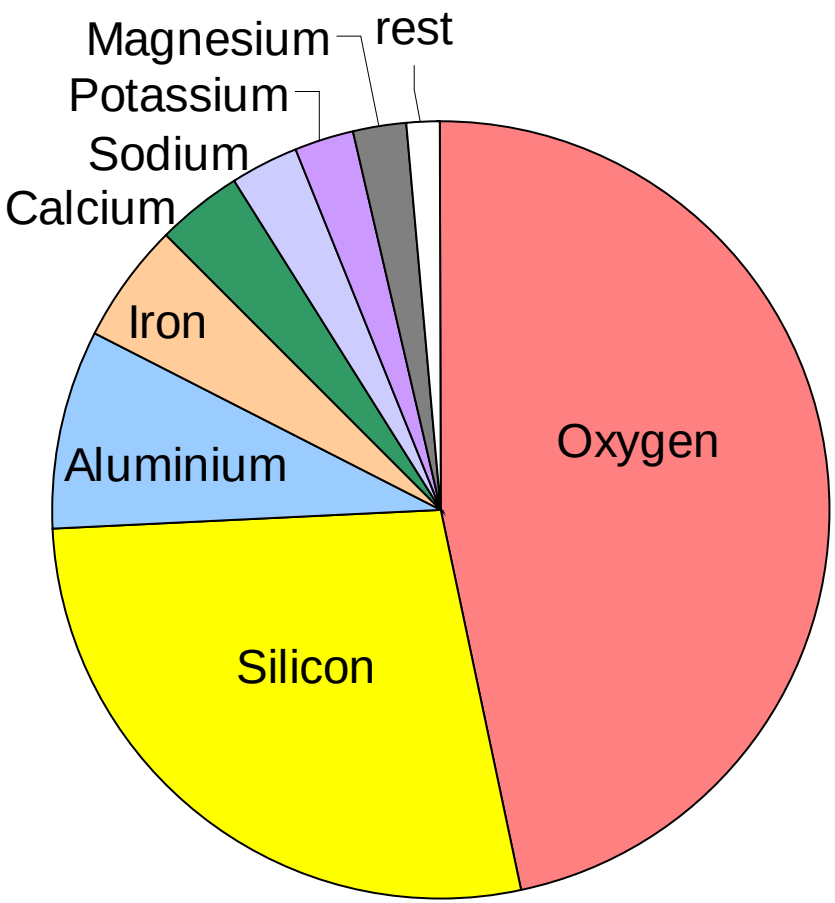
The Problem of Raw Materials Supply

- Global demand for concrete is well over 6 km^3/yr and increasing rapidly, especially in the emerging economies.

- To meet this demand, current world cement production is already in excess of 1.7 Gt/yr and also increasing rapidly.
  - This requires the mining of about 2 Gt/yr of limestone.
  - It gives rise to global CO_2 emissions of about 1.4 Gt/yr.

- Any potential replacements for current construction cements (which are all based on Portland clinkers) must be based on minerals available in quantities comparable to the demand, and well-distributed world-wide.
  - Cements based on less abundant minerals are unlikely to be produced in quantities large enough to have much impact on global CO_2 emissions.
  - Because of this, there are few real alternatives on a global scale.

Principal Elements in the Earth's Crust
(mass proportions)



Relevant Mineral Resources and their Global Distribution

Mineral	Resources and Distribution	Supply / Demand
Limestone (calcite):	Very abundant and very widespread	Very high
Gypsum + Anhydrite:	Abundant and fairly widespread	Fairly high
Bauxite (alumina): *Impure alumina sources:*	Abundant but poorly distributed *Very abundant (e.g. kaolin; laterites)*	Fairly high *Possible for cements*
Magnesite: (Magnesium carbonate)	Much less abundant than calcite, and *very poorly distributed.*	Adequate for magnesia *but not for cements.*
Phosphate Rock: (Calcium phosphate)	Fairly abundant, but *very poorly distributed*	Adequate for fertilizers *but not for cements.*
Iron Ore *(& processing residues)*	Very abundant and fairly widespread *(BF slag is by-product of iron extraction)*	High *(Slag used as cementitious)*
Coal *(& combustion residues)*	Very abundant and fairly widespread *(Fly ash and FGD gypsum are by-products)*	High *(Adequate for cements)*

Raw Materials-Derived CO_2 Emissions for Compounds of Actual or Potential Interest

Potential cement compound	Typical raw materials used:	Raw Materials CO_2 (t/t)
M (magnesia, periclase)	magnesite	1.09
C (calcia, quicklime)	limestone	0.79
C_3S (alite)	limestone + quartz	0.58
Portland cement clinker (OPC)	limestone + clay + iron ore	0.52
β-C_2S (belite)	limestone + quartz	0.51
C_3A (tricalcium aluminate)	limestone + bauxite	0.49
C_4AF (calcium aluminoferrite)	as above + iron ore	0.36
NS (sodium metasilicate)	soda + quartz	0.36
C$H½ (plaster) or C$$H_2$ (gypsum)	FGD gypsum (limestone + SO_2)	0.26 - 0.30
CA (monocalcium aluminate)	limestone + bauxite	0.28
$C_4A_3$$ (calcium sulfoaluminate)	as above + natural anhydrite	0.22
pozzolans (natural or man-made)	volcanic ashes, fly ashes, etc.	0 - ?
C$H½ (plaster) or C$$H_2$ (gypsum)	natural gypsum or anhydrite	0
calcite powder ($CaCO_3$)	natural limestone	0

Possible Alternatives to Portland Cements

- **Cements containing more alumina and sulfate than OPC:**
  - Calcium aluminate-based cements, calcium sulfoaluminate-based cements, metallurgical slag-based cements, etc.

- **Cements containing larger amounts of supplementary cementitious materials than permitted by current norms:**
  - High-volume fly ash cements, highly filled portland cements, alkali-activated pozzolanic cements, etc.

- **Many of these cements are already made for niche applications:**
  - However, their technologies need further improvement to become competitive with OPC for more general use at projected 2010 emissions trading levels.

Beyond 2010

- **Current well-proven approaches for reducing specific CO_2 emissions due to cement manufacture will be pushed to their practical limits:**
  - Maximize additions of supplementary cementitious materials in our cements
  - Maximize the energy efficiency of our cement manufacturing plants
  - Maximize recycling and use of by-products as fuels and raw materials

- **With the WWF, are looking into ways of increasing our use of renewable energy (wind, solar, etc.) in our global operations.**
  - We are ready to take ambitious initiatives in this field provided that they can provide sufficient shareholder value.

- **We are also investing in R&D aimed at developing the most promising of the alternative cement systems discussed here.**
  - Development of novel "Low-CO_2" cement technologies is likely to be a more attractive investment than more generic options such as sequestration.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