Entreprises pour l'Environnement

Scenarios for transition towards a low-carbon world in 2050 : What's at stake for heavy industries ?

Launched in 2004, the study *Scenarios for transition towards a low-carbon world in 2050 : What's at stake for heavy industries* explores how major industrial sectors will be impacted by a carbon constraint stabilizing atmospheric CO_2 concentration at 450 ppm. By means of an innovative hybrid modelling platform and ongoing dialogue between researchers and industrials, the study produces conclusions concerning both general climate policy as well as the economic response of industrial sectors—specifically of the steel, aluminium, cement, and sheet glass sectors, as well as of the energy sector.

OBJECTIVES OF THE STUDY

This study attempted to examine the **impact of a strong carbon constraint on major industrial sectors**, compatible with limiting global warming through CO_2 stabilization at 450 ppm by the end of the century.

In addition to the energy sector, the study focuses on **steel, aluminium, cement, and sheet glass** production, as these materials are the main inputs for the transport and housing sectors. As major GHG emitters, these industries are in a position to be significantly impacted by an overall carbon constraint.

One of the unique features of the study is that industrial transformation was not only analyzed through production technologies, but also through the demand for these industrial sectors. A strong carbon constraint is likely to lead to **major divergences in heavy material demand**, through changes in construction, infrastructure, energy provision networks, and vehicles.

Other development options were also explored, including a set of mechanisms going beyond the establishment of a CO_2 price, and focusing on **the role of infrastructures and the spatial organization of activities**. These elements reflect the choices at the disposition of governments regarding the energy content of development, a question particularly crucial in emerging countries.

The vocation of the study called for an explicit representation of the technological potentials for emissions reductions as well as of the macroeconomic and inter-sectoral interactions. This led to the development of **a hybrid modelling platform** allowing two models to hold a recursive dialogue with each other: the energy model POLES and the general economic equilibrium model Imaclim-R, including modules specific to the industrial sectors in question.

Ongoing communication with a steering committee throughout the study facilitated the ownership of the research by the industrials, as well as the management of the industrial sector modelling process.

Three principal scenarios were carried out :

REF	Reference scenario where there is dynamic global economic growth and no genuine carbon constraint.	
ST1	Scenario stabilizing CO_2 at 450 ppm, with the spread of industrial country-style development throughout the world.	
ST2	Scenario stabilizing CO_2 at 450 ppm by an evolution in development style made possible by adapted policies and measures regarding infrastructure, construction, and territory planning. Two variations of the scenario ST2 were also carried out:	
	VARCCS	Variation discarding or delaying the possibility of carbon capture and storage.
	VARDC	Variation delaying the implementation of a carbon constraint in developing countries by 5 years.

THE RESULTS

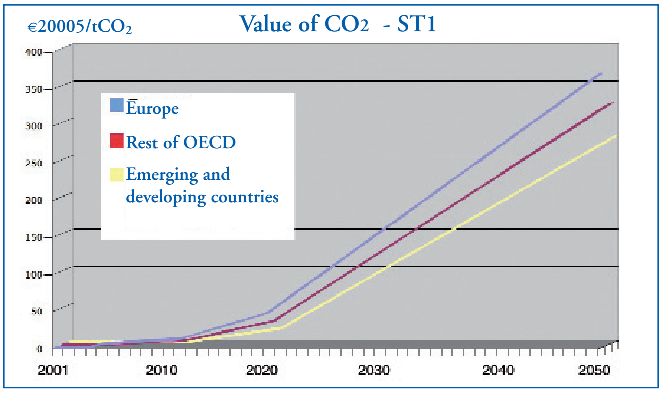
i. The reference scenario leads to climate impasse (REF scenario)

The REF scenario, in which current development trends continue—i.e. the spread of the industrial country way-of-life to the rest of the world—and where the carbon constraint remains weak (which more or less reflects the status quo) leads to a multiplication of world GDP by 4.5 in 2050 with respect to 2001. On the other hand, the strong growth of energy needs (multiplied by 2.5) mainly satisfied by fossil fuels (20 Gtoe in 2050 as opposed to 8 Gtoe in 2001) leads to a carbon emissions trajectory that is **unsustainable for the climate**, rising to 57 Gt of CO_2 in 2050 from 23,5 Gt in 2001.

ii. Only a robust carbon value can contain emissions in a scenario where industrial-style development is adopted worldwide (ST1 scenario)

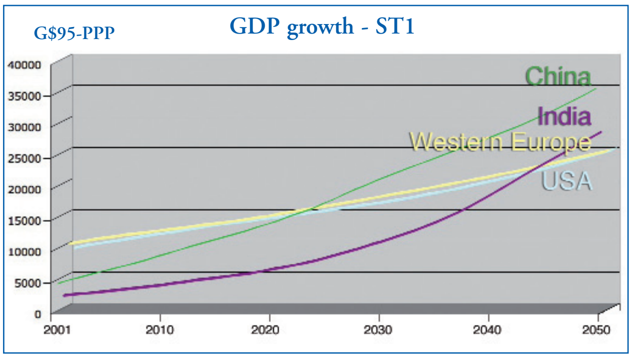
The ST1 scenario proposes a continuation of industrial country-style development, but imposes a carbon emissions envelope leading to atmospheric CO_2 stabilization at 450 ppm by the end of the 21st century. In this case, it is necessary to determine the trajectory of CO_2 values that will induce the necessary emissions reductions.

In the models, this carbon value is conceived as an indicator representing the totality of constraints, including taxation and regulations that can be put in place to reduce emissions in different sectors. The curve for the value of CO_2 takes off from 2008 onwards in Europe, 2013 in the U.S., and 2017 in non-OECD countries.

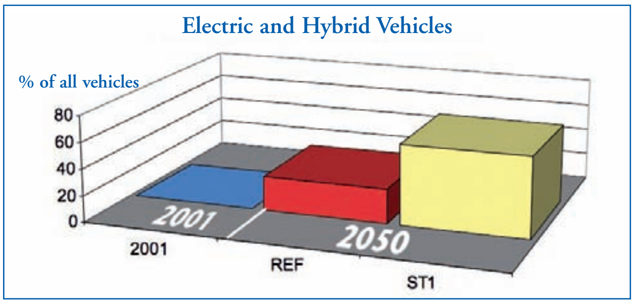


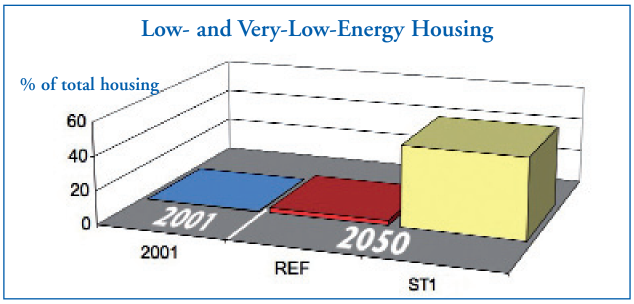
The most striking results of the ST1 scenario are :

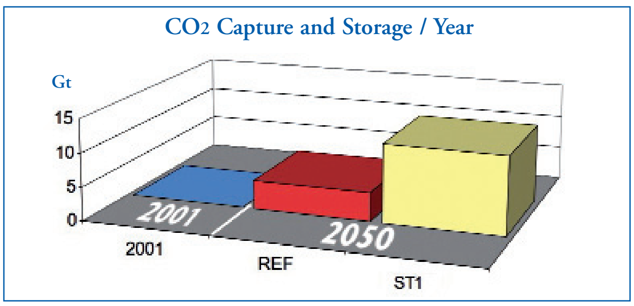
- **A high value of CO_2** (160 € - 220 € in 2030, and 350 € - 430 € in 2050) is required to obtain the desired emissions trajectory.
- **The GDP increases everywhere in the world in the ST1 scenario**, but behind this growth are diverse regional trajectories. In most regions, the carbon constraint leads to **a slight reduction in GDP growth with respect to the REF scenario**, on the order of less than 5% in 2050. But for some emerging and developing countries, India and China in particular, the impact of the transition cost and the share of energy in the household budget is such that supporting national or international measures will probably be necessary in order to ensure a more equitable distribution of efforts.



- This scenario is based on **optimistic hypotheses regarding the maturity and spread of the technologies allowing emissions reductions**: low- and very-low-energy housing; electric, hybrid, and hydrogen vehicles; and above all carbon capture and storage in power stations that make it possible to avoid 202 Gt of cumulative CO_2 emissions between 2020 and 2050. The following graphs describe these evolutions:







iii. A different development model reduces the economic constraint (ST2 scenario and variations)

The hypothesis that the style of economic development and choice of infrastructures remains largely unchanged—all while governments impose a very high carbon cost on their populations—was questioned at the conclusion of the ST1 scenario simulations. This doubt led to the elaboration of scenario ST2.

The impact of a different development style and spatial organization of activities (ST2 scénario)

This second scenario stabilizing CO_2 at 450 ppm was elaborated by adding to the increasing carbon value **new development choices regarding transport infrastructure and urban planning** within each world region, and also adding a **new organization of production systems.** These policies cover two different urban configurations, one with urban areas already fitted with heavy infrastructure, and another consisting of urban zones that will be organized in the next decades, particularly in developing countries.

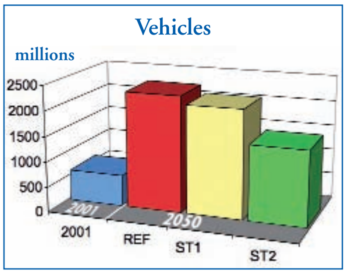
Two urban development models are projected, according to the local contexts : 1) a sparsely populated city fitted with a multimodal transport system and a decentralized energy production system 2) a dense city reducing the daily mobility needs of persons and merchandise. The choice of this second model in the majority of Asian cities in construction allows a significant reduction of mobility needs and a substantial decrease in automobile traffic compared to the other scenarios. A **significant reduction in mobility** is observed in densely populated cities, with the number of personal vehicles worldwide declining from 2.3 billion in the 2050 REF scenario to 1.5 billion in the 2050 ST2 scenario.

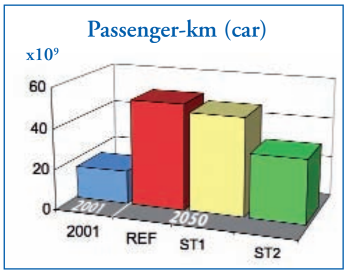
Heavy industry is organized on the basis on a **bringing together of production and consumption points**, and in some cases, on-site energy production.

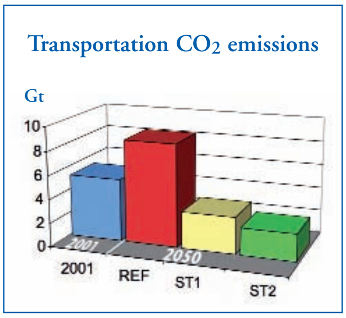
Collective choices leading to changes in spatial organization allows a **slight reduction in the carbon value** (-12%) required for the respect of the emissions envelope.

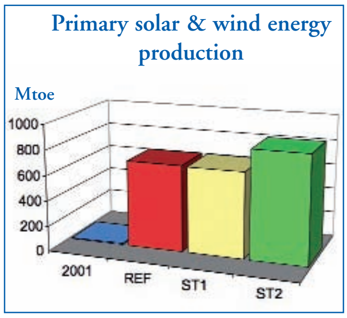
The **dispersed city model**—already established in some developed countries, and more intensive in terms of energy and space utilization—can still be compatible with climate stabilization if there is **widespread dissemination of decentralized energy** (particularly solar energy), **widespread habitat renovation** according to very low-energy standards, and adoption of electric vehicles optimized for usage in a multimodal system.

The combination of a growing carbon price-signal and deliberate choices for urban organization allow a significant reduction in the transition cost, and generates greater opportunities for growth in the long-term, by means of a significant reduction in the cost of the energy in household budgets.







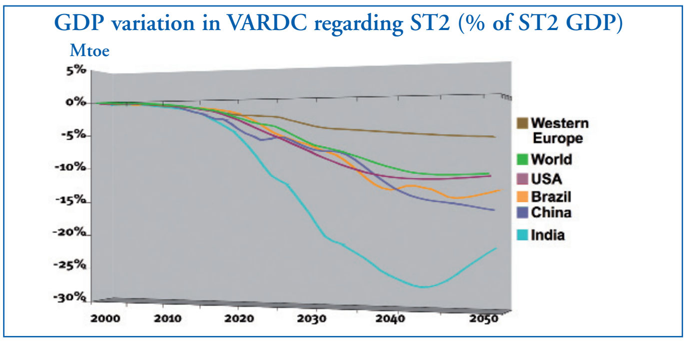


The importance of carbon capture and storage (Variation VARCCS of the ST2 scenario)

The implementation of the different styles of development and spatial organizations described above does not eliminate the **necessity to massively deploy low-carbon technologies in the electric sector.** The VARCCS scenario discards the possibility of carbon capture and storage in power stations before 2050, thus implying the imperative of a **stronger penetration of nuclear and renewable energy**, with respect to a scenario which is already heavily dependent on these energy sources. The additional cost of worldwide investment in this scenario would particularly affect emerging countries rich in carbon and experiencing very strong growth in electricity demand.

A limited window of opportunity to inflect emissions (VARDC variation of ST2)

The window of opportunity for reducing CO_2 emissions by combining a rising carbon value with sustainable development of territories is limited as time goes on. In the VARDC scenario where **climate policy is delayed until 2022 in non-OECD countries, there would be a significant and lasting slowdown in the world economy.** This additional cost is mostly due to the additional burden carried by emerging countries, more vulnerable to a growing carbon price due to the irreversibility of energy-intensive technical and organizational decisions.



SECTORAL IMPACTS OF THE DIFFERENT SCENARIOS

The below table summarizes the consumption in 2050 of the principal materials studied, as well as the electricity production mix. These materials serve as the main inputs for the transport and housing industries. The outputs of the scenarios show the evolution of these results by period and by region.

		2001	2050			
			REF	ST1	ST2	VARDC
Real GDP	G$95	41854	191210	179011	187014	166752
GDP per capita	$95	6847	21262	19905	20795	18542
CO_2 emissions	Gt	23,4	57,4	17,6	17,5	17,1
STEEL consumption	Mt	834	2013	2189	1982	1861
CEMENT consumption	Mt	1681	4933	5557	5719	5153
ALUMINUM consumption	Mt	34,9	122,7	119,6	106,7	99,5
SHEET GLASS consumption	Mt	35,2	105,9	127,5	92,6	87,7

Taken as a whole, with the hypotheses and data used, the **pursuit of the stabilization of atmospheric CO_2 concentration at 450 ppm** does not diminish heavy materials demand; it actually reinforces the demand for heavy materials. The stabilization scenarios change the demand structure for materials and opens new markets for superior value-added solutions.

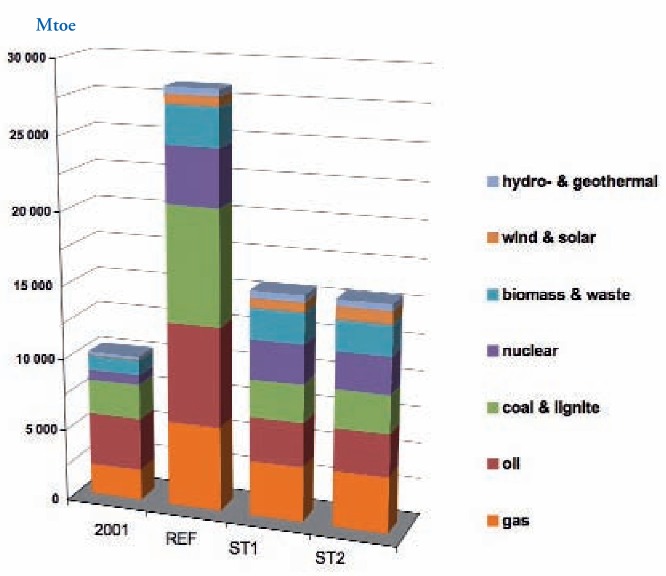
In the **ST2** scenario, steel demand is reduced by 10% with respect to ST1 due to the **reduced spread of the automobile**, a reduction that is partially compensated by an increase in steel demand for transport infrastructures of 2.2% per annum.

World cement demand grows at an average annual rate of 2.5% (3.3% per annum for the infrastructures and 2% for buildings). 75% of this demand is from Asia.

The **most dramatic decrease in material consumption** comes with the scenario variant where the developing countries delay their decarbonization efforts, thereby producing a slowdown in economic development.

The 450 ppm CO_2 scenarios mark **a disconnect between economic growth and primary energy demand**, which is reduced by almost half in the ST1 and ST2 scenarios with respect to the REF scenario in 2050. Fossil fuel use is more or less stabilized at its current level (with a reduction in oil production and an increase in gas production). The production of nuclear and renewable energy is also less than in the REF scenario, but occupies a larger percentage of the total.

Primary energy production



Electricity production

	2001	2050		
		REF	ST1	ST2
Electricity production (kTwh)	15,4	74	49,6	51,3
Fossil fuel	*9,9*	*39,5*	*20,2*	*20,4*
Nuclear	*2,6*	*18,0*	*12,6*	*11,8*
Wind & Solar	*0,04*	*5,4*	*5,6*	*7,4*

KEY MESSAGES

- A coherent strategy for the stabilization of CO_2 at the global level requires the **reinforcement and accelerated renovation of infrastructures**. Under these conditions, **the major materials producers** of steel, aluminum, cement, and glass can play a **leading role** in a context of increased demand, if they can adapt their production to the carbon constraint. Besides a **carbon cost**, a strong **political engagement** is necessary to set in motion the mutation of infrastructures and the mobilization of these sectors on a wide-enough scale to combat the greenhouse gas effect.

- Economic development based on the worldwide adoption of the lifestyle of OECD countries, and **without carbon constraint**, leads to a CO_2 emissions trajectory that is **climatically unsustainable** (57 Gt in 2050 as opposed to 23,5 Gt in 2001).

- The pursuit of the **stabilization of CO_2 atmospheric concentration at 450 ppm** before the end of the century, in combination with the pursuit of industrial country-style development, **would represent an extremely strong constraint on CO_2 emissions between now and 2050**. In this case, the value per ton of CO_2, considered as an indicator of a whole set of policies and measures, including emissions taxation, would be on the **order of 400 €/ton in 2050**.

- **Different development options for transport infrastructures and urban planning** in each region, combined with a growing price signal, allows a **significant reduction of the transition** cost toward CO_2 stabilization at 450 ppm, and produces higher economic growth opportunities in the long-term, thanks to a more rapid reduction of household energy costs.

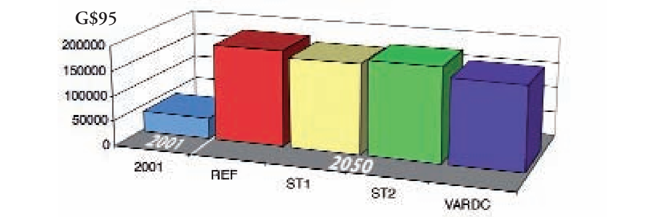
- The scenarios reducing emissions and stabilizing atmospheric CO_2 concentrations at 450 ppm not only require a significant increase in energy efficiency, but also **massive and rapid deployment of new technologies**: very-low energy buildings, electric vehicles, carbon capture and sequestration in power stations, and increasing recourse to nuclear and renewable energy sources. The additional worldwide investment cost would particularly affect emerging countries where there is strong growth in energy demand.

- In most regions of the world, the macroeconomic cost of the climate constraint is concentrated on **two or three decades of transition** toward a low-carbon system. By 2050, climate policy allows the majority of the regions to **attain or even surpass the GDP of the reference scenario**, notably because of measures protecting economies from anticipated tensions on fossil fuels.

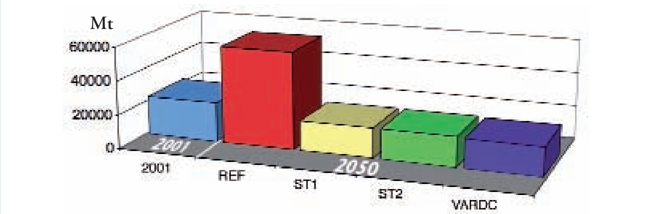
- For certain emerging and developing countries, the transition cost is such that **supporting national and international measures would be necessary**, in order to ensure a more equitable distribution of emissions reduction costs.

- **A delay in the launch of climate policy in non-OECD countries would lead to a significant and lasting global economic slowdown**. This additional cost is notably due to the additional burden carried by emerging countries, which would be more vulnerable to a rising carbon cost, because of the irreversibility of energy-intensive technical and organizational choices.

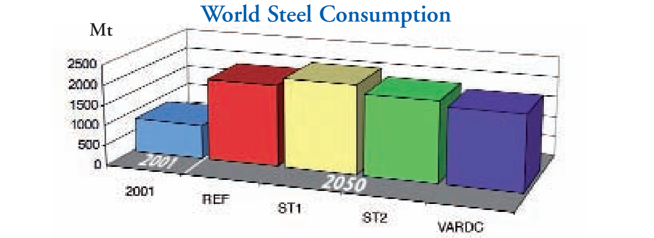
World Real GDP



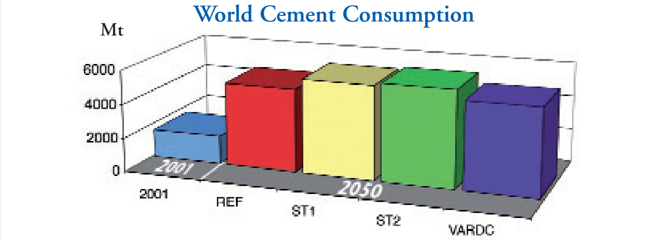
World CO_2 Emissions



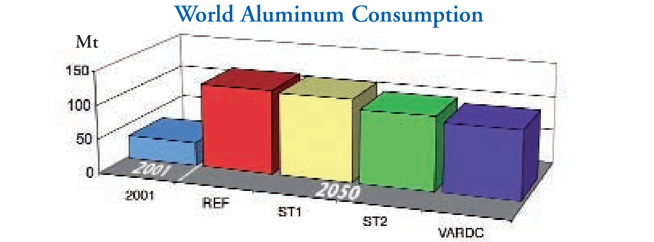
World Steel Consumption



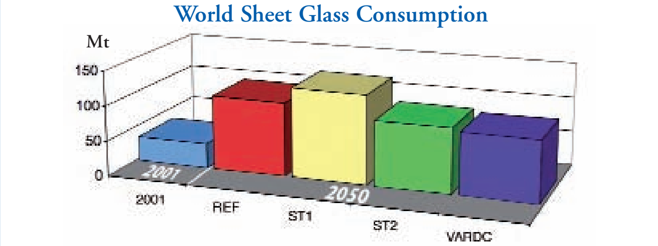
World Cement Consumption



World Aluminum Consumption



World Sheet Glass Consumption



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Entreprises pour l'Environnement (EpE) is an association created in 1992 that brings together fifty large companies looking to better integrate the environment in their strategic decisions and everyday management, and to advance the sustainable development agenda. Its members represent all economic, industry, and service sectors. EpE is the French partner of the World Business Council for Sustainable Development.
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