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ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

SECTORAL TRANSITION PLAN FOR THE FRENCH CEMENT INDUSTRY

EXPERTISES

CEMENT

Summary report

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Joint editorial

Arnaud LEROY
President of ADEME

The manufacturing industry accounts for about a fifth of France's greenhouse gas emissions. It figures increasingly in debate on climate change – debate that has been further amplified by the Covid crisis and a desire to revive a resilient French manufacturing industry. Energy-intensive sectors (cement, steel, chemicals, etc.) in particular – which involve only a limited number of stakeholders but accounting for the bulk of emissions – are key in successfully delivering this transition. In France, the National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone or SNBC) has set an ambitious target for the manufacturing industry: reduce its greenhouse gas emissions by 81% between 2015 and 2050

This challenge has led ADEME to formulate – as part of the Finance ClimAct project financed by the European Commission – decarbonisation pathways for the nine main energy-intensive sectors in France. These Sectoral Transition Plans are of strategic importance: they provide a framework for achieving the SNBC targets through a co-construction process involving various stakeholders from the French heavy industrial sectors. ADEME is thus fully delivering on its mission as a state operator, sharing its expertise and supporting manufacturers in implementing climate policies. The transition to a more sustainable production model is all the more necessary since the industry supplies materials to the economy's main sectors: construction, transport, agriculture, etc. Furthermore, by ruthlessly testing the resilience of our supply chains, the Covid-19 pandemic has put issues such as relocation and industrial sovereignty back at the heart of the debate.

Heavy industry is therefore facing a number of major technical and economic challenges on its journey towards deep decarbonisation, where energy substitution is not always sufficient. This is the case for the cement industry, for which non-energy emissions (two-thirds of total emissions) require innovation and new business models. The cement industry is the first sector that has enabled us to experiment with the Sectoral Transition Plan methodology, in close collaboration with the French Cement Industry Association (SFIC) and cement manufacturers. As a pilot sector, we would like to thank all the stakeholders for their active involvement in this project. We are virtually certain that the conclusions of this first Sectoral Transition Plan will help the industry to become more resilient and will feed the discussions and the public debate about its decarbonisation. All we have to do now is to turn words into actions and continue this work with other sectors, starting with steel, aluminium and chemicals.

François PETRY
President
of the SFIC

The cement industry would like to pay tribute to the work undertaken by ADEME's teams in this unprecedented industrial planning exercise. There are many lessons to be learned and they must be integrated into future public policies at national and European level. Technical solutions other than those mentioned in this study – such as CO_2 capture and its use in derivative products – can be used to develop other scenarios that will help us maintain our existing production facilities in France. Government support will also be needed for these promising solutions.

To ensure that achieving carbon neutrality does not come at the expense of the country's industrial activity, it is more critical than ever to support our companies in this transition:

• The investments that will have to be made will not be profitable without a carbon border adjustment mechanism that guarantees European manufacturers fair competition with non-European imports. Maintaining free allowances is essential while this carbon border adjustment mechanism is being validated and prior to it being accepted by stakeholders engaged in international trade.

• Without a clear overview of the options available for accessing decarbonised and competitive energy, it will not be possible to secure the necessary funding to make this transition a success.

• Disruptive technologies, such as carbon capture, utilisation and storage, are all essential for achieving deep decarbonisation. They will require policy and financial support to bolster the deployment and pooling of the necessary infrastructure.

Our societies use cement – an essential component of concrete – for meeting housing and transport requirements; it is also a strong material that can withstand all the challenges posed by global warming; if we can reduce its carbon footprint, we can continue using it to support societal changes in a low-carbon economy.

1. Context

1.1 From the National Low Carbon Strategy to the Sectoral Transition Plan

The French National Low Carbon Strategy (Stratégie Nationale Bas Carbone or SNBC) defines the path France intends to take to achieve carbon neutrality by 2050. The commitment was made following the 21st Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC), and was revised in 2020. For the French industry, the SNBC sets an 81% reduction target in greenhouse gas (GHG) emissions compared to 2015 levels. While the literature provides some guidelines on industrial decarbonisation (e.g. giving preference to carbon-free energy and a circular economy), what they involve and their cost at an operational level have not been detailed. Yet industrialists need medium-term visibility in order to invest. Indeed, as industrial facilities have a lifespan of several decades, today's investments will have consequences up until 2050. The Sectoral Transition Plans are developed within this time frame. The aim is also for public authorities to introduce effective supporting policies to encourage investments aligned with the 81% reduction target.

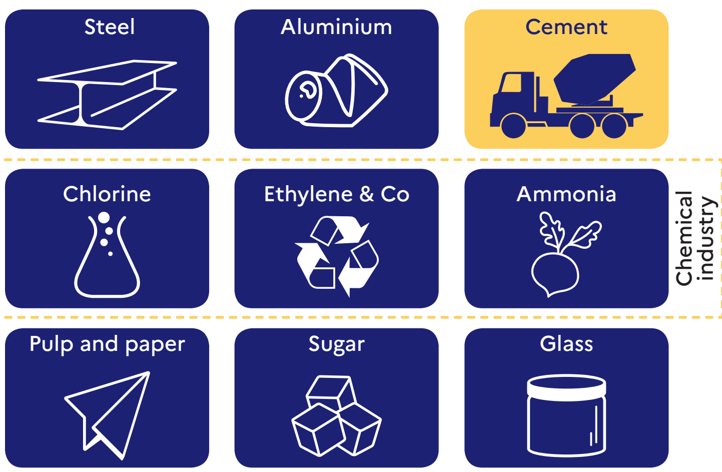
By working hand-in-hand with key sectoral players, **ADEME seeks to offer visibility to industry and investors, as well as public authorities. The project is a continuation of the work carried out for the SNBC,** dividing heavy industry into nine sectors (shown in Figure 1) to put forward specific decarbonisation solutions for each sector.

The vast majority of the research described in the national, European and international literature focuses primarily on the industrial transition from a technological standpoint. This project adopts a more comprehensive overview that covers considerations related to markets, costs, financing and jobs. As part of a European LIFE[1] program entitled Finance ClimAct[2], these transition plans are based on cross-analysis of the deployment of decarbonisation technologies and their costs, to anticipate financing needs, the effects on competitiveness and on market developments in terms of demand and competition by 2050. The effects on employment and the possible changes in skills required to adapt to the sector's transition are also discussed in the Sectoral Transition Plans, as well as territorial anchorage and the degree of a region's dependence on the industrial sector.

Following the summary report on the first technical and economic results, the purpose of this document is to deliver the key findings from the Sectoral Transition Plan applied to the French cement sector.
The full report – including a more in-depth description of the cement industry, hypotheses and analyses of the results conducted through modelling – should be published in autumn 2021.

Ultimately, this work should lead to the formulation of "public-private" action plans to speed up the transition of these key sectors.

Figure 1. The nine industrial sectors to be covered by an STP.



[1] The LIFE program is the EU's funding instrumentfor hte environment and climate action created in 1992.
The funding period 2014-2020 had a budget of EUR 3,4 billion.

[2] https://presse.ademe.fr/2019/12/finance-climact-mobilisation-pour-un-plan-daction-sur-la-finance-durable.html?hilite=%27FINANCE%27%2C%27CLIMACT%27

Project

Finance ClimAct

With the contribution of the European Union LIFE program

30
people working full time on the project

18
million euro budget

5
years

Project objectives

Regulation & supervision

French and EU plans on sustainable finance

CTH

Observatory

Stress-tests

Households

Facilitating retail investors' investment decisions based on environmental objectives.

The project supports our understanding of retail investors' expectations regarding sustainability and their ability to act upon them (Investors Preferences) and puts in place a clear and credible information to identify sustainable financial products (Labels).

Preference

Greenfin

European Ecolabel

Financial institutions

Taking climate change into account in financial sector management and supervision.

The project equips financial institutions and their supervisors to integrate climate into risk management while promoting long termism (PACTA and Climate Stress-Tests) and to encourage transparency regarding the contribution of institutions to the mitigation of climate change and their resilience to its consequences (Climate Transparency Hub and Sustainable Finance Observatory).

PACTA

ACT

INVEEST

Industry

Favour investment in energy efficiency and the low-carbon economy, in line with the National Low Carbon Strategy and the European Green Pact.

The project aims to train and equip companies and their financiers to develop low-carbon strategies (ACT) and enable the implementation of energy efficiency and low-carbon projects in the most emissive industrial sectors (INVEEST and Sectoral Transition Plans).

Sectoral Transition Plans

Projet partners

ACPR, AMF, Banque de France, Finance for Tomorrow, GreenFlex, Institute for Climate Economics, Ministry of Ecological Transition, 2° Investing Initiative

1.2 The French cement industry: some figures

16.5

million tonnes

Cement production in 2018

(down 23% in 10 years) or about 0.5% of world production and about 9% of European production, for domestic consumption of about 18.6 million tonnes (Mt).

27 clinker production sites in 2018 and 5 industrials groups:

LafargeHolcim, Ciments Calcia, Eqiom, Vicat and Imerys Aluminates (formerly Kerneos which produces calcium aluminate cement for specific applications).

Between 2010 and 2016, the turnover generated by the cement industry was around EUR 2.5 billion (in current euros).

Energy consumption represents about 30% of production cost in this sector.

Clinker imports

(an intermediary product used in cement and responsible for nearly all of a cement plant's CO_2 emissions), were quite stable until 2013,

BUT INCREASED 5- TO 6- FOLD BETWEEN 2013 AND 2018

mainly from Spain and countries in North Africa and the Middle East. In 2018, the net balance of clinker imports represented about 5% of the clinker used in mainland France

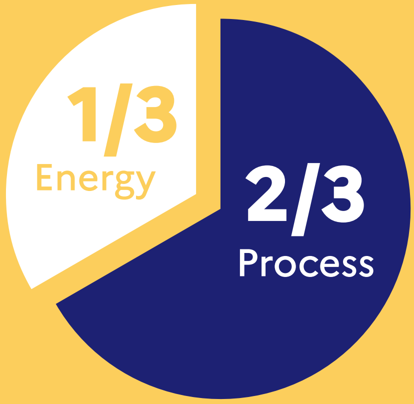
Foreign cement trade

France imports almost 3 times more cement than it exports. The net import balance of 1.9 Mt in 2018 represented about 10% of domestic consumption, which has remained constant for the past 10 years. Trade in cement is mainly with neighbouring countries such as Spain, Belgium and Italy.

5 000

direct jobs
on average since 2010
spread throughout the country and 25,000 indirect jobs.

Origin of cement industry emissions



One third of the emissions generated by the cement industry are related to energy combustion. The rest are "process" emissions resulting from limestone decomposition.

63%

of cement consumption
is in the building sector and 37% in civil engineering.

Approximately 10 million tonnes of CO_2eq emitted each year – that's

12.5% OF THE INDUSTRY'S GREENHOUSE GAS EMISSIONS

and 2% of total emissions in France.

2. Summary for decision makers

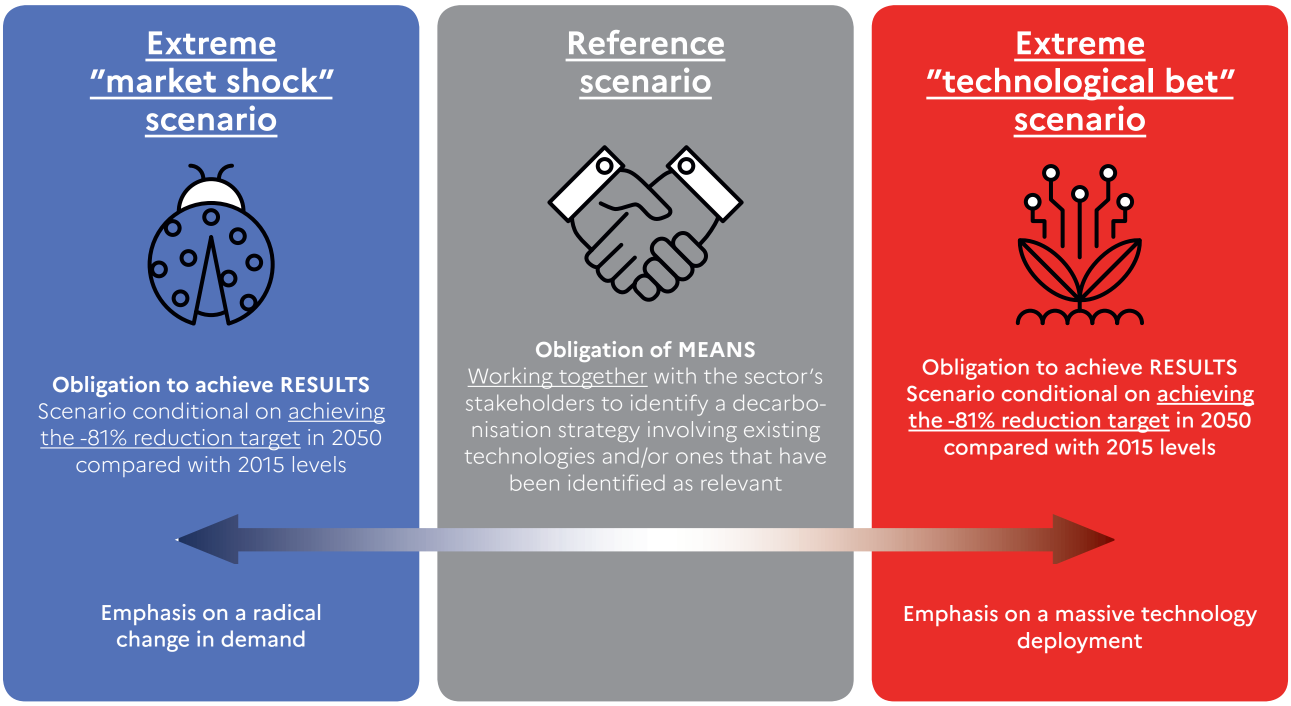
Two types of modelling to illustrate possible futures

The modelling of transition scenarios for the cement industry has been divided into two types of exercise:

• **A *forecasting* exercise** for which existing decarbonisation levers and those with clearly identified potential have been modelled. Referred to as the **"reference" scenario, CO_2 emissions are reduced by 54% in 2050 compared with 2015 levels,** in the best-case situation[3]. Since the 81% reduction target set in the SNBC is not achieved, this scenario highlights the **technical, organisational and economic challenges involved in the deep decarbonisation of the cement industry, hence the need to consider more ambitious pathways. This reference scenario was developed and structured in consultation with the cement industry.**

• **A *backcasting* exercise** in which two scenarios reaching the 81% reduction target have been developed. One scenario is based on a demand shock, and the other is based on the large-scale and ambitious deployment of technical solutions. Although the forecasting initiative opens up a multitude of possibilities, it was decided to represent two extreme visions of the world at either end of the spectrum, as illustrated by Figure 2. The purpose of the **"technological bet" scenario** and the **"market shock" scenario** is not to formulate predictions nor to demonstrate that these are the only two possible alternatives. Instead, they aim to shed light on the necessary conditions to decarbonise the sector – whatever the future may hold – to fuel the public debate. Unlike the reference scenario, this exercise was conducted internally within ADEME. These scenarios were intentionally developed on the basis of two extreme visions, from which new valuable learnings could be drawn.

Figure 2. Methodological framework for producing the scenarios.



[3] The "reference" scenario described in this document is an extension of the SNBC-ADEME's scenario included in the "Sectoral Transition Plan for the French cement industry: First techno-economic results –Summary report"; https://librairie.ademe.fr/changement-climatique-et-energie/4406-ciment-premiers-resultats-technico-economiques-9791029717161.html?search_query=ciment&results=13

An analysis that combines a technological pathway...

Regardless of the scenario, the first step of the project was to build a technological pathway that combines various decarbonisation levers in a coherent and realistic way, while quantifying the impacts on energy consumption, emission intensity, and production costs. Decarbonisation technologies have been thoroughly researched and modelled, starting with mature solutions and/or ones that have been identified as having high decarbonisation potential. Based on existing information in the literature and discussions with manufacturers, more innovative solutions have also been studied and included in certain technological pathways according to their relevance. Moreover, in line with the co-construction approach of the cement STP and in response to the initial interim results, a special technology innovation workshop was held in autumn 2020 bringing together cement manufacturers and technical experts. The aim was to qualify and identify new levers for possible inclusion in a decarbonisation pathway.

...and evolution in cement demand...

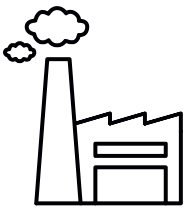
To assess the sector's total emissions, various technological pathways have been coupled with projections in cement production levels until 2050. These projections differ depending on the scenario considered. They have been obtained using PEPIT0, a modelling tool used to estimate demand levels from cement-consuming sectors (construction, transport, etc.) translated into material production pathways afterwards[4] (clinker, steel, etc.).

The demand trajectories have been developed in accordance with the transitional contexts of each scenario.

In particular, for the two new extreme scenarios, the development of the demand trajectory was coordinated with the technological pathway in order to describe coherent worlds and to make them as credible as possible.

... to infer CO_2 impacts...

Table 1. Summary of the main results of the Sectoral Transition Plan for the French cement industry – decarbonisation levels and change in demand.



	"Market shock" scenario	Reference scenario	"Technological bet" scenario
Level of decarbonisation achieved in 2050 compared with 2015	-81%	-54%	-83%
Change in national cement demand in 2050 compared with 2015	-60%	-13%	-6%

The evolution in cement demand by 2050 illustrate the fundamentally opposite worlds in which these two "extreme" scenarios take place. While the supply and demand equilibrium for new constructions in the "technological bet" scenario is driven by a classic market-based approach, the 60% demand reduction in the "market shock" scenario is the result of a **very binding regulatory framework for tackling land artificialisation, thereby slashing the number of new constructions and the associated need for cement.**

[4] The "Industrial transition - a prospective exercise for energy and materials: towards a production level modeliling tool" report is available from this link: https://www.ademe.fr/transition-industrielle-prospective-energie-matiere-vers-outil-modelisation-niveaux-production. The PEPITO tool can be provided free of charge upon request by writing to: transition.industrie@ademe.fr

...and the economic issues correlated to the price of CO_2

Estimated CAPEX	EUR 240 million	EUR 4.4 billion	EUR 7.7 billion
Change in unit production cost (average across production facilities)	+85%	+130%	+130%

Logically, the estimate of the required investments strongly depends on the level of technological deployment: almost EUR 8 billion seem necessary to achieve deep decarbonisation in a scenario in which innovation plays a predominant role. In addition to capital expenditure, the assumption of a CO_2 price trajectory reaching EUR 180/tCO_2 in 2050 leads to a production cost increase in all scenarios. Without any investment, the cost of inaction would triple the cement production cost, whereas investing in decarbonisation would "only" double it.

×2

Order of magnitude of the impact of the transition scenarios on the production cost

×3

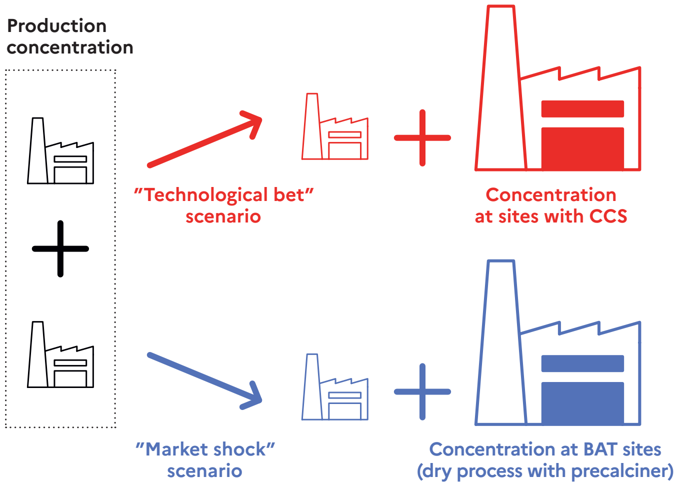
Order of magnitude of the impact of the price of CO_2 on the production cost without investment in decarbonisation

Structural assumptions for the extreme scenarios

In the reference scenario, many obstacles remain to drill down into deeper decarbonisation levels. These are essentially related to the inherent limitations of the CCS technology and to the availability of clinker substitutes. In response to these limitations and to achieve the SNBC target, strong assumptions had to be taken in the extreme scenarios.

Three of these are worth highlighting (see section 4 for more details):

- Within the **"technological bet"** scenario framework, a **new CO_2 storage area has been assumed** in order to increase the number of cement plants that are eligible the deployment of CCS. At the same time, **clinker production is concentrated** at plants located in CCS zones. This means that in practice, during upgrading operations, the rotary kilns at these cement plants are replaced by new more effective ones and with a higher production capacity.
- Within the **"market shock" scenario** framework, other issues than those to do with decarbonisation have been considered in order to reflect broader societal concerns. In this case, the establishment of a more binding regulatory framework to meet the **target of net zero soil artificialisation has been assumed. This involves a significant fall in the number of new buildings every year** from 2030 onwards. This assumption of a significantly smaller market for cement manufacturers also tends to reflect an environment in which resources such as sand and **water become increasingly scarce and thus more expensive.** This limits construction prospects, particularly of second homes.
- In these two extreme alternative scenarios, to justify the most realistic and effective deployment of decarbonisation levers, **structural reorganisations in the cement production fleet across the country have been assumed** in a context where national cement demand is falling while the need for new less carbon-intensive binders is increasing. In keeping with the assumption that clinker production is concentrated at certain specific production sites (those eligible to CCS or already operating on the Best Available Techniques), it has been imagined that other cement plants would be converted into clinker grinding plants or repurposed for the production of calcined clay or new alternative binders. In reality, these choices are based on the specific strategies of each major cement company, according to their own decision-making criteria.



Main limitations of scenario building exercises

All the main findings presented are the result of an ambitious exercise that aim to model decarbonisation scenarios for the cement industry by 2050. This exercise is based on an innovative methodology that is not without its limitations, especially in terms of scope and access to data.

This aspect should be borne in mind while reading through the document and the reader should maintain critical thinking when drawing conclusions from this work, particularly by considering the following elements:

• **A common emission reduction target for different industrial sectors:** The SNBC's 81% target for the manufacturing industry has been applied to the cement industry subsector as an input constraint to the scenario-building exercise. This decision offers the advantage of defining a common framework for all sectors covered by a Sectoral Transition Plan. However, this assumption closes the door to a more flexible allocation of emission reduction targets between industrial sectors for which abatement potentials and associated decarbonisation efforts may be different. An analysis of all sectors could eventually lead to the definition of more appropriate targets.

• **A broader vision of the cement sector highly dependent on external factors:** Although this exercise focuses on the cement sector's ability to reduce its direct carbon emissions, it aims to provide the broadest possible view of the key factors driving this change. It was therefore necessary to make – directly or indirectly – assumptions regarding parameters external to the cement sector, such as energy and carbon prices, demographics or the availability and price of raw materials such as limestone from quarries, blast furnace slag or calcined clays.

• **And yet, the approach could be enriched with new driving factors from other economic stakeholders:** Indeed, as the cement industry is a node in a complex economy that interacts with upstream and downstream entities (which are themselves evolving), a comprehensive systemic approach to decarbonising the sector would require a vision that goes far beyond the perimeter of this sector, and therefore numerous assumptions regarding other nodes making up the system. This is the aim of ADEME's more global 2050 Energy Resources Prospective project, which will be published by the end of 2021.

➜ Picture by EQIOM/DUNKERQUE

• **Moreover, as in any strategic foresight exercise, there is an infinite number of possible assumptions and an infinite number of combinations of these assumptions. Consequently, each scenario could be further discussed and improved with the various stakeholders involved.** Without investing it with a predictive nature, the trend-based scenario was developed on the basis of a broad stakeholder engagement process – also to consolidate the proposed innovative methodology. The "technological bet" and the "market shock" scenarios, however, are the result of internal work conducted by ADEME, and did not involve a stakeholder consultation process. Yet, both scenarios reflect technically plausible worlds, more or less desirable and the decisions made by industry companies and policy makers would be significantly different from those in the reference scenario. Other worlds could be very well explored to reveal new insights, such as a decarbonisation scenario where a national CO_2 transport network would link up all emitting industrial sites to storage areas and/or a market would emerge for products based on CO_2 capture (Carbon Capture and Usage). Thereafter, anyone who wishes to do so should feel free to propose alternative visions. The modelling tools will be made available, as will all of the literature sources and assumptions in the more comprehensive report. The aim is to help stakeholders assimilate the exercise while showing the same transparency standards regarding the assumptions made and acknowledging the limitations of the exercise.

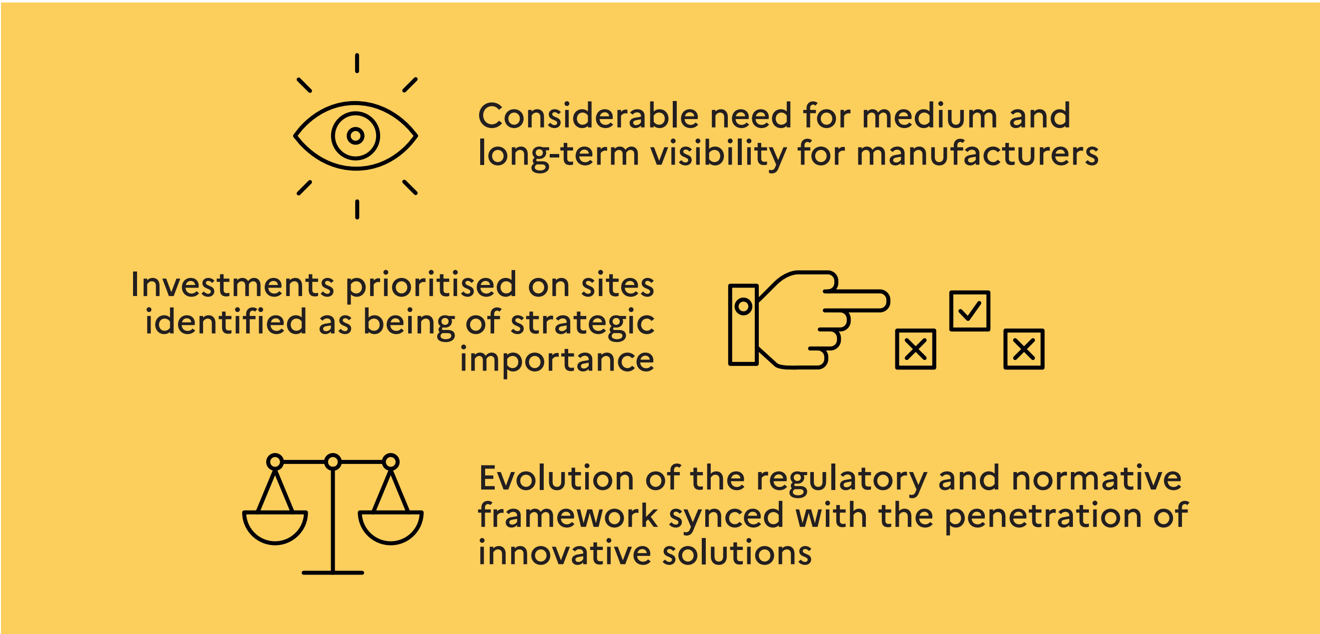
In addition, the full report that goes with this summary also provides information about the contexts of the scenarios and how the transition could materialize in terms of employment and potential industrial strategies. The full report aims to feed additional elements from the results presented in this summary into the reflection. These elements making up the analyses are of a more academic nature and are based on a an extended review of the scientific literature and other publics sources. Given the extended cross-referencing effort of all these sources by the authors, these analyses are intended to be as objective as possible and to reflect the current state of knowledge on the decarbonisation of the cement sector.

Fundamental prerequisites for decarbonising the cement industry!

Despite these limitations, the exploration of the cement industry scenarios has brought to light some major conditions to achieve deep decarbonisation. Three lessons (listed below) stand out in particular.

To try to meet these requirements, several courses of action have been identified through a multi-stakeholder consultation process.

Figure 3. Fundamental prerequisites for decarbonising the cement industry.



AN ESSENTIAL CONSULTATION PROCESS TO IDENTIFY THE INITIATIVES TO BE IMPLEMENTED

Following the publication of the first results of the cement STP, a consultation process was initiated with numerous stakeholders in the form of bilateral interviews. The aim was to formulate courses of action to speed up decarbonisation of the cement industry, which would be shared by a wide range of stakeholders across the value chain. The goal was also that – by the end of this consultation process – each stakeholder would be able to adopt one or several actions that they would then attempt to implement at their own level.

A summary of all the actions was proposed for discussion at a workshop held on 15 December 2020 with all stakeholders (cement manufacturers, construction companies, representatives of the concrete industry, technical experts from the building sector, NGOs, think tanks, academics, representatives of competing materials). After this workshop, several stakeholders manifested their willingness to adopt and to work on certain actions through a written contribution. All of the proposed actions will be included in the full detailed report. Each essential prerequisite is illustrated by an example of a course of action.

➜ Picture by Bannafarsai_Stock/Shutterstock.com

Public procurement: stimulating demand for "low-carbon" concrete

Environmental clauses are gradually being introduced to public contracts as a result of changes in the legal framework, pressure from civil society and the sharing of experiences across buyers' networks. That said, there is still only very limited information about the CO_2 content of concrete despite that manufacturers are launching new products. There is no shared definition of a "low-carbon" concrete that buyers can easily refer to, and CO_2 content can vary significantly depending on usage. With more than 200,000 public purchasers and therefore potential project managers, public procurement constitutes a powerful lever to drive change in market practices. It can send positive signals to stimulate a market for "low-carbon" concrete. Supporting "pilot contracts" to test the integration of a carbon criterion and/or a minimum threshold for the incorporation of Recycled Concrete Aggregates (RCA) into concrete is essential to encourage decarbonisation initiatives in the cement sector. As an example, two complementary approaches can be considered when drafting specifications:

- **Technical specification:** condition access to the public market on compliance with a CO_2 performance threshold for concrete by setting a percentage for GHG emissions reduction compared with equivalent class concrete composed solely of CEM I as a reference, and/or a minimum integration of RCA per cubic meter of concrete.
- **Award criterion:** give greater weight to the CO_2 performance criterion of concrete and/or their RCA content, and indicate it in public tenders. This weighting could be greater for infrastructure projects where there are no substitutes for concrete and where there are no regulations such as the recently introduced RE2020 environmental regulation for buildings.

While it is necessary to introduce new environmental clauses into public procurement contracts, local authorities are also encouraged to share and disseminate experiences, especially via regional buyers' networks to upscale the market for "low-carbon" concrete.

Considerable need for medium and long-term visibility for manufacturers

In the descriptions of the various transition contexts, the deployment of technological solutions is conditioned by a certain level of confidence from cement manufacturers and investors regarding the long-term financial sustainability of their assets. As a matter of fact, like many heavy industries, investments in the cement sector are very capital-intensive and industrial assets often span several decades. **The need for visibility is therefore essential if major investments are to be made. Within the scenarios' storytelling, visibility is considered through CO_2 prices, the availability of resources and the market outlook.** These are often the three main factors guiding strategic decisions taken by cement companies. Managing these uncertainties allows companies to more effectively assess potential OPEX savings. Indeed, high CAPEX costs of technologies are often put forward but, when adopted early, these technologies can generate future returns in a context where energy and CO_2 prices are most likely to rise. In a "technological bet" scenario, visibility is even more necessary since the pathway assumes a form of planning for renovating cement plants, reorganising the industrial facilities and deploying CCS in certain specific areas.

Investments prioritised on sites identified as being of strategic importance

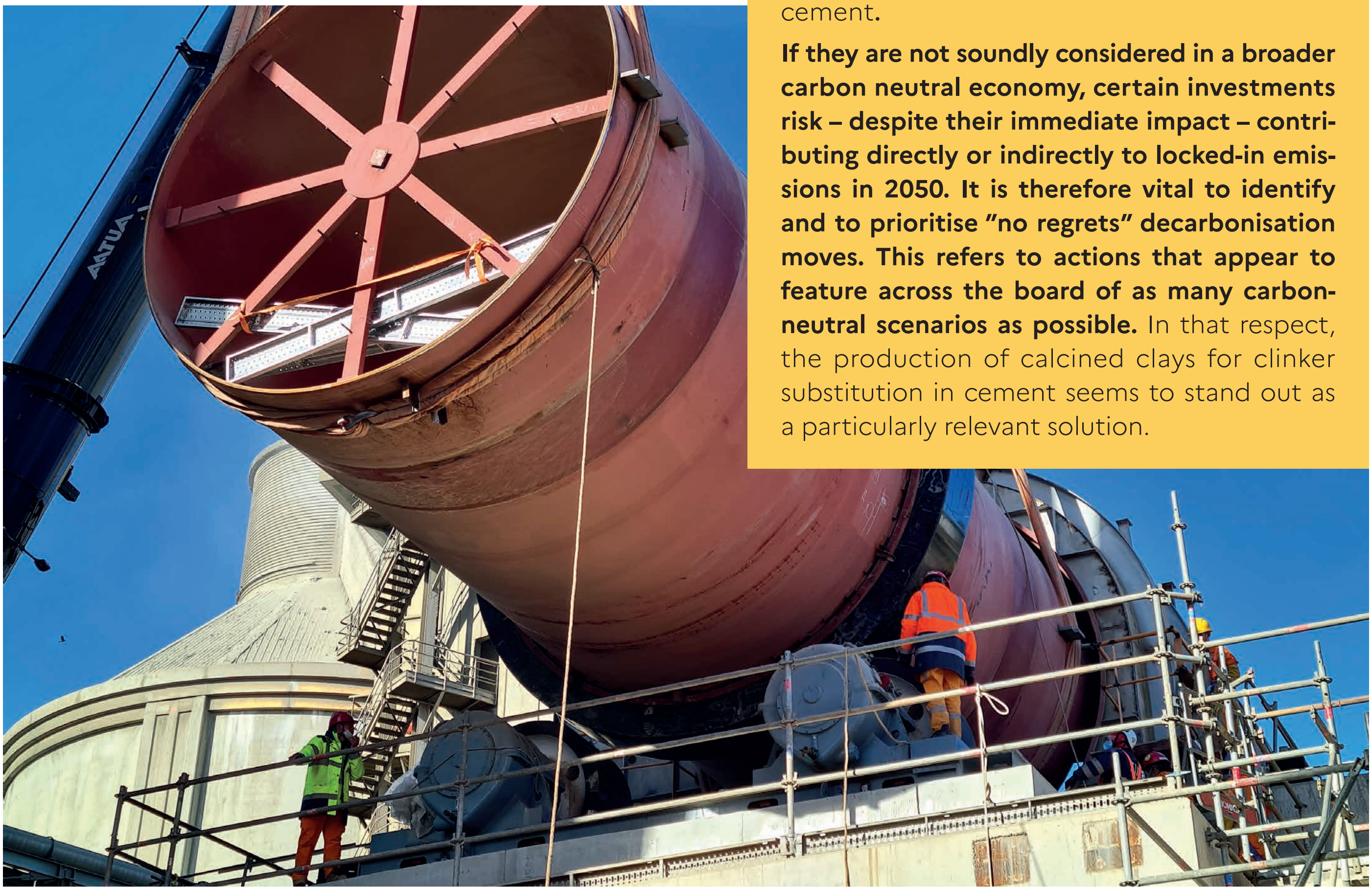
Given the high investment cost of some technologies and the inherent difficulties in decarbonising the cement process, there is a significant risk of stranded assets and locked-in emissions by 2050. To manage this risk as effectively as possible, the scenarios assume targeted investments at sites with the best chance to fit within a carbon neutral economy in the very long term. This is particularly the case in the "market shock" and "technological bet" scenarios, where production facilities have been restructured in order to reach the SNBC's targets – hence the need to adopt a comprehensive overview of the industrial fleet. Nevertheless, investments decisions will ultimately be up to the cement groups according to their respective industrial and decarbonisation strategies. It should also be noted that investment choices on certain sites will come with the responsibility of supporting the conversion of other sites and associated jobs. The socioeconomic cost of this conversion has not been quantified in this analysis, but it will need to be integrated into all public policies to support stakeholders and territories to achieve carbon neutrality.

Cement manufacturers: adapting innovation strategies

The main challenges related to technology lie in high upfront capital costs, especially in upgrading cement plants to a new BAT process, and in the integration of clinker substitutes. On the other hand, the research for innovative solutions that would further cut into process emissions appears more essential than ever. That alone justifies the exploration of a "technological bet" scenario where new innovative solutions have been modelled, such as new alternative binders and the accelerated recarbonation of recycled concrete aggregates before reuse in fresh concrete. This latest solution also contributes to a more circular economy as it involves the recycling of construction waste. Besides, it can contribute to unlocking new decarbonisation techniques in the long term, such as selective separation of demolition waste and the reuse of concrete fines as a clinker substitute in new cement.

If they are not soundly considered in a broader carbon neutral economy, certain investments risk – despite their immediate impact – contributing directly or indirectly to locked-in emissions in 2050. It is therefore vital to identify and to prioritise "no regrets" decarbonisation moves. This refers to actions that appear to feature across the board of as many carbon-neutral scenarios as possible. In that respect, the production of calcined clays for clinker substitution in cement seems to stand out as a particularly relevant solution.

➜ Picture by LAFARGEHOLCIM FRANCE/Martres travaux four 2



Evolution of the regulatory and normative framework synced with the penetration of innovative solutions

→ Picture by bogdanhoda/Shutterstock.com

Deploying decarbonisation levers as presented in the scenarios presupposes that there are no regulatory or normative obstacles. However, in reality, a number of technically mature solutions face regulatory and normative constraints at national and European level. Some of the new, less carbon-intensive binders are no longer even considered a technical novelty by the time they are finally adopted by the construction industry. The example of CCS is also interesting in this respect: there are still many legal barriers to overcome, such as complex international coordination in the case of offshore storage, or the accounting of negative emissions which is not yet recognised at European level. These obstacles can make certain technologies less attractive to the industry. Similarly, the acceptability of new products by market players has not been questioned in the various scenarios. However, slow market uptake of less carbon-intensive binders on construction sites is clearly limiting the decarbonisation of the cement industry. By way of another example, the financing of certain CCU projects are at present hindered by a lack of visibility on future allocation of CO_2 emissions and accounting methods under the EU ETS regulation.

Construction sector: the need for improved consultation and training

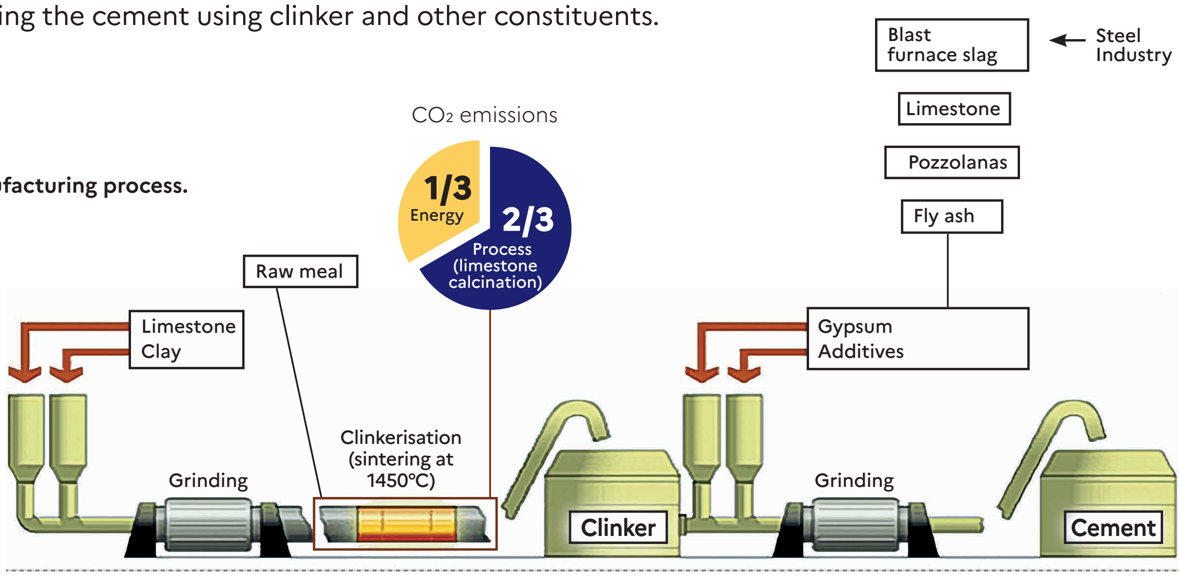
Discussions held with downstream stakeholders in the value chain and industry experts have spotlighted a strong need for consultation among the various parties involved in a construction project. For all parties concerned – contracting authorities, architects, prime contractors and construction companies **– there is significant room for enhancing cooperation especially when it comes to limiting the use of concrete and improving overall material efficiency in a construction project.** At the same time, reducing the clinker-to-cement ratio is identified as a major decarbonisation lever for the sector. However, resulting binders modify concrete properties and require adjusting concrete preparation and placing. This is sometimes a barrier to the widespread adoption of new innovative products and, in turn, to the standardisation of these products. Therefore, training contract operators so they can use these new products seems essential. This will create the conditions needed to deploy new low-carbon cementitious products, as well as optimising material usage in buildings.

3. Decarbonising by continuing with the current approach: a first reference scenario for 2050

3.1 The cement manufacturing process: essential to understand the sector's main challenge toward deep decarbonisation

The manufacturing process of ordinary Portland cement as shown in Figure 4 consists in two main separate steps: manufacturing clinker and preparing the cement using clinker and other constituents.

Figure 4.
Cement manufacturing process.



➜ Computer graphic by Eric Menneteau, CNRS

Clinker is a dark grey constituent that can be considered the active ingredient: it provides hydraulic properties to the binder, i.e. it hardens on contact with water. Clinker is obtained by sintering a previously ground mixture of limestone (80%) and clay (20%) which are relatively abundant raw materials and well distributed geographically. This is partly why the cement industry is very localised and cement is not widely transported. Sintering takes place in a rotary kiln at 1450°C and this process accounts for the vast majority of a cement plant's energy consumption. It is at this stage that almost all the emissions of a cement plant are released: about a third are due to thermal energy consumption and two thirds are due to the chemical reaction of limestone calcination during which limestone (chemical formula $CaCO_3$) decomposes into calcium oxide (quicklime, CaO) and CO_2. Once the clinker is formed, it cools down on leaving the kiln and the restored heat is recycled back for clinker production and elsewhere in the process.

The clinker is then ground and mixed with other constituents to produce cement with the required properties. These secondary constituents can be either industrial by-products (such as blast furnace slag, which is a by-product of the steel industry, or fly ash from coal power plants) or naturally occurring materials (such as limestone and natural pozzolanas). Cement can be prepared independently in clinker grinding units. This is a trend that has been observed for several years: some stakeholders import clinker from abroad (notably from North Africa and the Middle East) and produce cement for the French market in grinding plants generally located near sea ports. This practice is an obvious form of carbon leakage. Another way of producing cement is to mix CEM I (composed of about 95% ground clinker) with other secondary constituents such as micronized limestone filler. Besides, cement production in mixing plants has been eligible to the French NF Hydraulic Binder certification for several years now. Note that grinding stations and mixing plants do not generate direct emissions since clinker is produced at other sites.

3.2 Formulation of a reference scenario by combining technology and demand

A technology roadmap based on mature technologies...

The adoption of transition technologies has been modelled to put forward decarbonisation pathways for the French cement industry in a coherent and realistic narrative. In consultation with relevant stakeholders and experts, five well-identified decarbonisation levers shown in Figure 5 and that are applicable (and in some cases, already partly implemented) to the cement industry, have been modelled in an Excel tool. The total investment required to implement these levers and their impact on the cement production cost were also part of the modelling.

... coupled with assumptions on the evolution of cement demand

With 9.5 million tonnes of cement consumed in France in 2014, the new-build sector accounts for 53% of total demand (18 Mt used in 2014 across all sectors). Figure 6 shows the material flows from the extraction of limestone and clay required for clinker production through to the final consumption of concrete in various applications. In addition to the importance of new builds for the sector, it should be noted that the proportion of cement in concrete is remarkably low compared with the high proportion of sand and aggregate.

Figure 5. Main decarbonisation levers for the cement industry[5][6].

Lever 1
Upgrading
In the industry jargon, "upgrading" refers to the conversion of an old cement plant into a new and more efficient one, integrating the most efficient process currently known. This decarbonisation lever is therefore solely an energy efficiency measure.

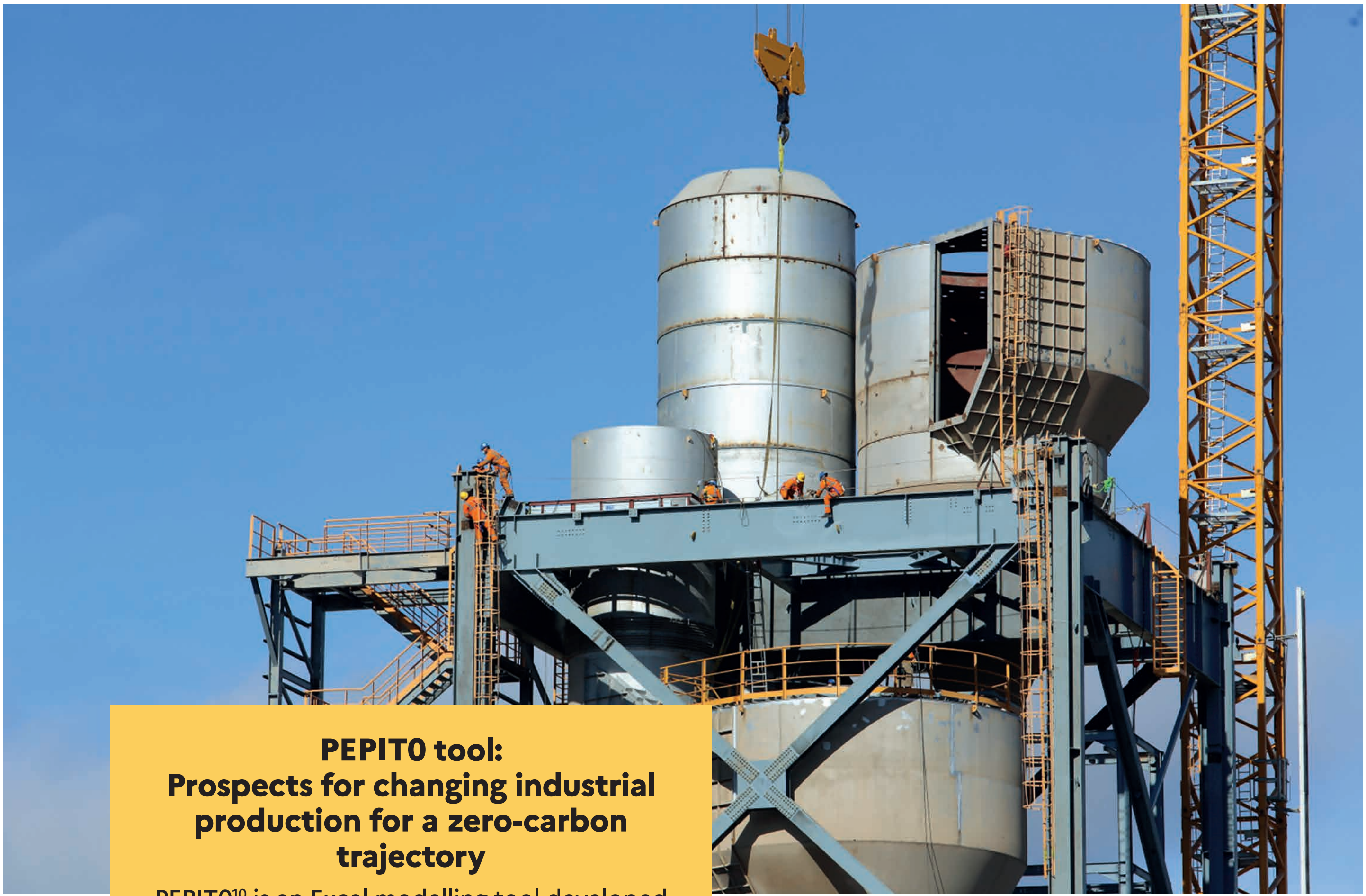
Lever 2
Fuel mix
Energy consumption accounts for about a third of a cement plant's emissions. These can be reduced by replacing fossil fuels (coal and petroleum coke) with lower-carbon fuels incorporating a biomass fraction.

Lever 3
Clinker content
Clinker is an intermediate material that goes into the final composition of cement and its production represents almost all the emissions of a cement plant. Producing cement with a lower clinker content results in lower clinker production, thereby reducing overall emmissions (including blended cement plants).

Lever 4
Incremental
The "incremental" category consists of a group of seven technologies more or less commonly used in the sector that can contribute in small ways to the decarbonisation of cement plants, in an "incremental" way. The modelling of these technologies is based on ECRA and BREF data.

Lever 5
Carbon Capture and Storage (CCS)
This technology, not yet deployed on an industrial scale, aims to trap the CO_2 in an impermeable geological formation and can therefore theoretically cut out almost all of a site's emissions. It first involves capturing, purifying and concentrating CO_2 from industrial sites and then transporting it to a storage site.

[5] ECRA (European Cement Research Academy): https://ecra-online.org/fileadmin/redaktion/files/pdf/CSI_ECRA_Technology_Papers_2017.pdf
[6] BREF (Best Available Techniques Reference Document): https://aida.ineris.fr/sites/default/files/directive_ied/CLM_BREF_042013.pdf



→ Picture by LAFARGEHOLCIM FRANCE/Martres travaux tour

PEPIT0 tool: Prospects for changing industrial production for a zero-carbon trajectory

PEPIT0[10] is an Excel modelling tool developed in partnership with the NEGAWATT ASSOCIATION that aims to assess the levels of demand for basic materials from the 9 most energy-intensive industrial sectors (steel, aluminium, cement, glass, chlorine, ammonia, ethylene, pulp and paper, and sugar).
The model takes as an input the evolution of the main consuming sectors for these materials (mechanical industry, textile, transport, electrical industry etc.) which is based on assumptions made up to 2050 on a set of more than 200 parameters (demographics, recycling rate, per capita consumption of capital goods, average distance travelled by vehicle, etc.).
The PEPIT0 tool can be made available free of charge on request by writing to: transition.industrie@ademe.fr

The change in the pace of construction by 2050 is therefore the main driving factor for the cement market. As an example, it has been estimated that a 10% reduction in the number of new builds (houses and collective housing) would result in a decrease of about 3% in cement production (all other things being equal, without any change in current construction systems and practices). Apart from buildings, changes in road construction and renewable energy capacity have also been taken into account in future demand. **In the reference scenario, evolution in demand (modelled using the PEPIT0 tool, see box opposite) aims to reflect a broader transition context in which decarbonisation technologies would be adopted.** A similar method was used to produce the two other extreme scenarios: "market shock" scenario and "technological bet" scenario.

[7] INSEE study: "374,000 additional housing units every year between 2010 and 2015" (https://www.insee.fr/fr/statistiques/3572689#titre-bloc-14)

[8] INSEE study also shows that the share occupied by main residences in this growth in stock observed over the last decade has fallen in favour of vacant housing and second homes.

[9] According to INSEE, vacant housing accounted for 8.4% of the 36.3 million housing and second homes. (https://www.insee.fr/fr/statistiques/3676693?sommaire=3696937)

[10] Industrial transition - a prospective exercise for energy and materials: towards a tool for modelling production levels (https://www.ademe.fr/transition-industrielle-prospective-energie-matiere-vers-outil-modelisation-niveaux-production)

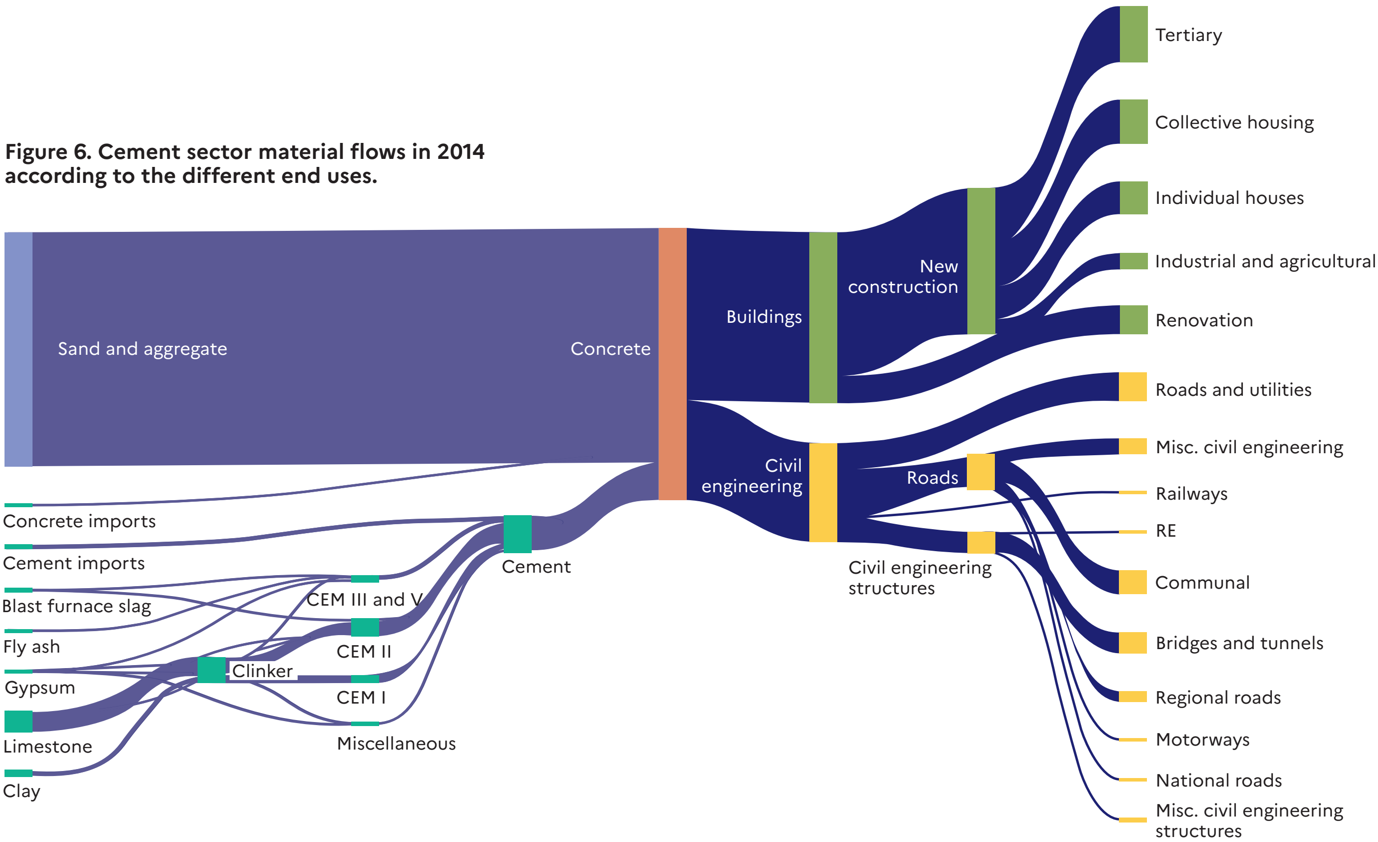
In this reference scenario, a greater degree of policy engagement from public authorities is considered (in comparison with current trends).

This is mainly reflected in regulatory constraints on the number of new builds and more specifically, a gradual decrease in the number of new single-family houses, reaching -50% by 2050 compared with 2014 (ADEME calculation based on assumptions from the SNBC). This assumption refers only to the number of new builds each year (which is a flow) and not in the existing housing stock. The voluntary reduction of new builds can be motivated by certain recent trends: over the last decade, according to the INSEE[7], the average rate of increase in the number of housing units was around the double that of population growth. To cope with the population increase by 2050, new construction will also have to be more dedicated to main residences rather than second homes[8]. Similarly, so-called "vacant"[9] housing will be leveraged and offered on the market. The use of wood as an alternative material in new construction is increasing in tertiary and collective housing (10% and 20% respectively by 2050) where it competes with concrete. Nonetheless, it should be noted that concrete is likely to remain a premium material for certain types of construction where opportunities for substitution are limited. Given their marginal share in concrete consumption, the development of renewable energies – especially wind – is not sufficient to offset the decrease in the demand for concrete, and therefore cement.

➜ Picture by CIMENTS CALCIA/Clinker

Furthermore, although adaptation to climate change could in principle lead to greater use of construction materials (e.g. rebuilding of infrastructure, dykes, etc.), the resulting cement needs have not been specifically quantified in the present analysis.

Figure 6. Cement sector material flows in 2014 according to the different end uses.



3.3 Identified technical solutions will not be sufficient to close the emission gap by 2050

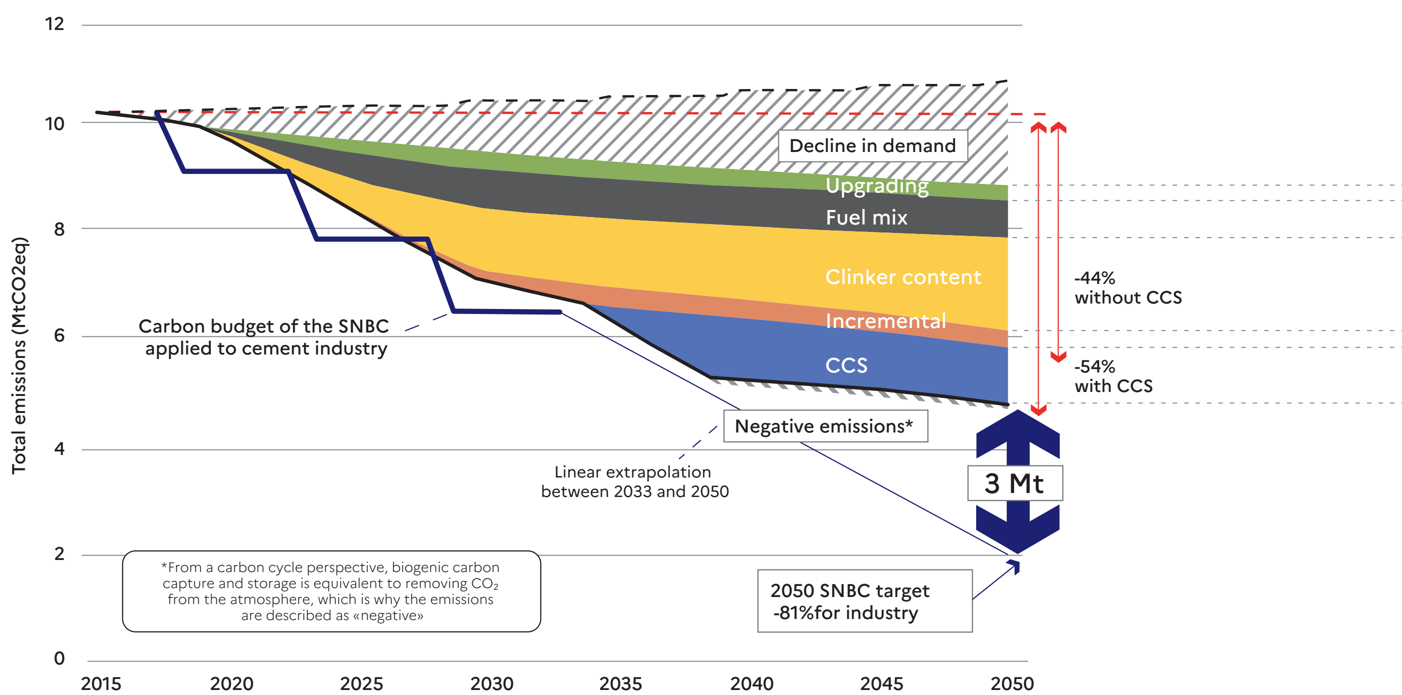
An emission trajectory aligned with targets until a post-2040 decoupling

In the reference scenario, in which the reduction in demand has been modelled according to the assumptions of the National Low Carbon Strategy, total emissions from the cement sector are expected to decrease by almost 15% under this single assumption of declining production. If all the identified decarbonisation levers were implemented in this scenario (upgrading, fuel switching, reduction of clinker content and incremental improvements), this would result in emissions reduction of around 44%, without Carbon Capture and Storage (CCS) technology.

When including CCS - which, according to an analysis conducted by ADEME, could only be considered at five cement plants in the reference scenario, excluding CCU and CO_2 transport infrastructure - the overall emissions reduction would be 54% by 2050 compared with 2015 levels (Figure 7). An extra cut of around 3 $MtCO_2$-eq would be needed to reach the SNBC target by 2050. In this scenario, the evolution of the sector's emissions closely follows the SNBC trajectory until 2040 where it stalls due to the lack of additional technological solutions. The SNBC sets an emissions reduction target of 35% for the industry between 2015 and 2030. The new European plan on energy and climate presented in September 2020 by the European Commission sets a 25% reduction target for the manufacturing industry between 2015 and 2030, which equates to annual emissions of 7.7 $MtCO_2$-eq in 2030 for the cement industry. In 2030, this European target, which is less ambitious than its equivalent SNBC target, is reached and even exceeded with the proposed technological pathway.

Figure 7 also shows – for information purposes – the negative emissions induced by the capture and storage of the fraction of biogenic CO_2 contained in the emission stream of cement plants. **If they were accounted for in the decarbonisation pathway of the sector, negative emissions would only contribute very marginally to emission abatement – around 1 to 2%.** If negative emissions stand out so poorly in the final balance, it is because of the limited number of sites with access to CCS and the low fraction of biogenic CO_2 in the emissions of a plant. Even if the thermal mix was fully decarbonised and only biomass fuel was used, about two-thirds of fossil CO_2 would still remain from the calcination of limestone.

Figure 7. Reference scenario – Decarbonisation pathway for the cement sector and associated abatement costs.



Dynamic calculation of the abatement cost based on the production cost

While the purpose of the abatement cost is to estimate the cost associated with deploying a technology to abate a tonne of CO_2, calculation methodologies differ in the literature which can yield different conclusions regarding the opportunity for a company to invest in a certain technology and the sizing of public subsidies. In the reference scenario and the two alternative scenarios further detailed in section 4, a dynamic approach was adopted. It consists in measuring the annual cost or gain associated with the adoption of a technology compared to a baseline situation where the technology would not be adopted. Unlike a static approach where only capital expenditure (CAPEX) and a constant production volume could be taken into account, a dynamic method captures the evolution of carbon and energy prices through variation in operational costs (OPEX) as highlighted in Equation 1. For cement manufacturers, potential OPEX savings may arise as the investment cost of the technology is paid back in the long run. Similarly, taking into account the evolution of production volumes makes it possible to reflect the impact of a potential market shock on the technology's abatement cost. This methodology for calculating the dynamic abatement cost has been named "discounted cumulative abatement cost" in this work. It has been used in the reference and the "technological bet" scenarios because of the pivotal role given to technology in these two universes as opposed to the "market shock" scenario. The assumption of a reduction and phase-out of free allocation under the EU ETS scheme between 2025 and 2030, together with an upward trajectory for the CO_2 price were considered in the modelling (see section 5 for more details).

Equation 1. Formula for calculating the discounted cumulative abatement cost (cumac)

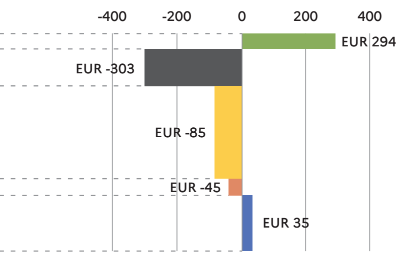
$$Ca_i = \frac{\textit{Total costs}}{\textit{Total } CO_2 \textit{emissions avoided}} = \left[\sum_{t=1}^{D_i} \frac{(CAPEX_{i,t} + \Delta\, OPEX_t \times Q_t)}{(1 + r^{act})^{t-1}}\right] \times \left[\frac{1}{\sum_{t=1}^{D_i} Q_t \times (\Delta\, intCO_2)}\right]$$

with D_i the lifetime of technology i, Q_t the production level in year t, r^{act} the discount rate, and $\Delta intCO_2$ the variation of the emission intensity of cement as a result of implementing technology i.

A purely "economic" approach to decarbonisation and a purely "economic" reading of the abatement curve as represented on Figure 7 would give priority to the cheapest levers in the merit order. With this approach, fuel switching should rank first given the value of its abatement cost of EUR -303 per tonne of avoided CO_2, reflecting significant OPEX savings once the investment is made. However, in practice, achieving such level of biomass and waste integration in the thermal mix is only technically feasible when facilities are upgraded to the Best Available Techniques (i.e. dry process with precalciner). Yet, upgrading a cement kiln is very capital-intensive which is reflected in a notably high abatement cost of EUR 294/ tCO_2[11]. A techno-economic approach has therefore been chosen in this work, where operational feasibility is taken into account in investment decisions of the industrial groups along with potential support from public authorities. Zooming into CCS, only the on-site CO_2 capture technology and the OPEX associated with transport and storage have been modelled.

Accounting for the cost of transport and storage as an OPEX from the perspective of the cement industry can be interpreted as if the investment in the infrastructure was born by another entity, most likely public authorities, and therefore, it underestimates the abatement cost from a broader societal point of view.

"Cumac" abatement cost curve in EUR/tonne of CO_2 avoided



How to interpret the abatement cost curve?

For each decarbonisation lever, the higher the rectangle (vertical axis), the greater the emission reduction potential. For example, the incremental lever offers less emissions reduction than CCS despite a lower abatement cost.

When the abatement cost of a technology is negative (horizontal axis), its adoption results in OPEX savings that more than offset the initial investment. The reason the abatement costs presented here are so different from values usually found in the literature is that assumptions regarding demand evolution and the price of CO_2 are included in the calculation unlike most common approaches.

A higher CO_2 price trajectory would lower abatement cost values. The technologies would become more "cost-effective" because the initial investment (excluding the cost of capital) would be more quickly amortised by the OPEX savings generated.

[11] These are average figures for the industrial fleet and may mask disparities between each reference plant.

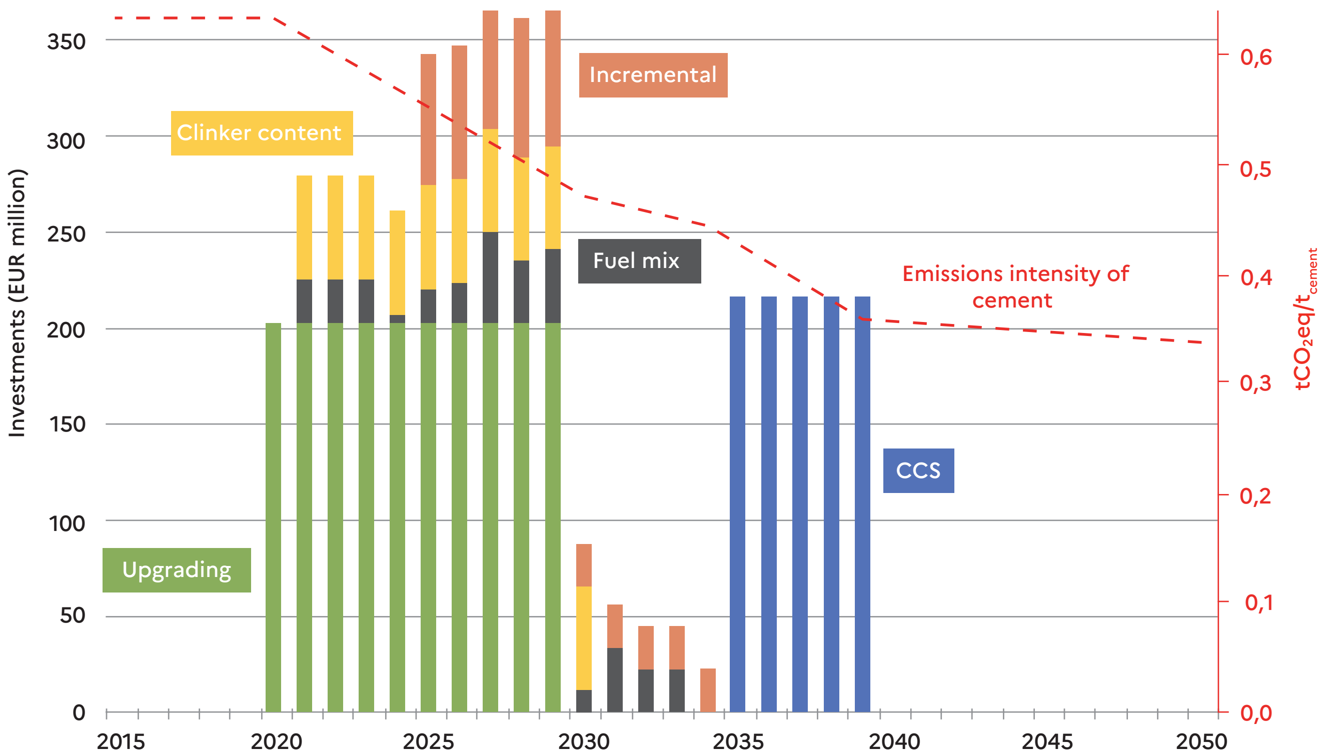
3.4 Massive investments to be made now, not only to develop innovative technologies!

The cumulated amount of investments needed to implement these decarbonisation levers has been estimated at about **EUR 3.3 billion without CCS for the entire French cement sector** (Figure 8). 60% of these investments are used to upgrade cement plants (by installing new state-of-the-art kilns close to BAT performance levels). Considering that upgrading of a plant is a technically mature lever that can be deployed in the short and medium term, investments are highly concentrated at the early stage of the decarbonisation pathway – i.e., between 2020 and 2030[12]. When adding up the investments needed for CCS (only the capture technology for the plants identified as "eligible", and not the infrastructure for transport and storage), the total investment is estimated at around **EUR 4.4 billion**. While waiting for the roll-out of CCS starting in 2035, the period 2030-2035 is marked by a "trough" or slowdown in investment.

To put these figures in perspective, **the average tangible investment over the period 2013-2017 for the cement, lime and plaster industry (NAF code 23.5) amounts to EUR 172 million per year[13] or approximately EUR 5.2 billion cumulatively over 30 years.** Thus, assuming that the cement sector captures the bulk of the investment made in the cement, limestone and plaster industry, the modelled pathway appears consistent with the scale of cement industry investments.

The reference scenario shows that the scale of investments should be maintained while accelerating them over a period of 10 years, and not 30 years.

Figure 8. Reference scenario – Investment forecast in the cement sector and evolution in emissions intensity (excluding capital cost).



[12] Best Available Techniques (BAT) identified in the European BREF documents: https://aida.ineris.fr/sites/default/files/directive_ied/CLM_BREF_042013.pdf

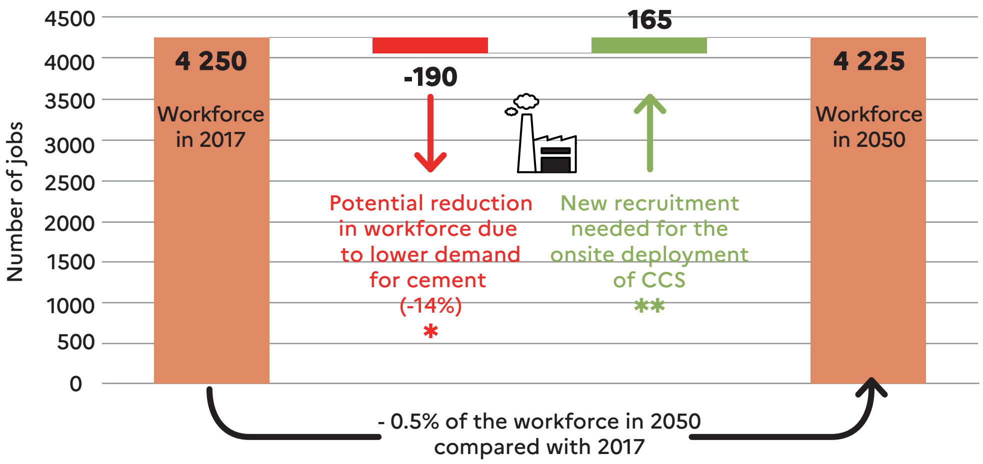
[13] Estimate based on INSEE data: https://www.insee.fr/fr/statistiques/4226063?sommaire=4226092

3.5 Limited impact on overall direct employment but with a contrasted picture across territories

With an average of 4500 employees for the period 2007-2017, the cement industry represents about 0.2% of total manufacturing jobs in France (with slight annual variations). The slowdown in construction activity following the 2007 economic crisis partly explains **the 10.5% reduction in the cement sector's workforce over the last decade[14].** This historical downward trend can be compared with projections for 2050 shown in Figure 9. The reference scenario forecasting exercise unveils a very limited knock-on effect on **the number of direct jobs (-0.5%).** This is because the shrinking in the workforce caused by lower demand for cement is offset by the new recruitment needed for the onsite deployment of CCS.

For every direct job on the cement plant, it has been assumed that five indirect jobs are created for the supply of intermediate goods and services. Similarly, **a ratio of one direct job for seven indirect jobs in the production of concrete has been assumed[15]**. When looking ahead to 2050, it is estimated that 950 indirect jobs will be lost and 1300 jobs will be lost downstream based on these ratios. Regarding downstream job losses more specifically, all things being equal, this equates to about 4.5% of the total jobs associated with concrete production, whereas between 2007-2017, there was a fall of about 15% (or 5000 jobs). This was due in particular to a decline in demand for cement from the construction sector. At the same time, the need for **training and for the development of new skills has been brought up on many occasions by stakeholders operating in downstream sectors.** This is all the more essential that new products developed by cement manufacturers have to be used in the construction industry. This "sectoral" approach and the estimates associated with it do not suggest that there will be changes to the way employees are distributed between cement manufacturers and their various sites. The strategies that companies are employing to adapt to the market and to the production of "low-carbon" cement can indeed vary significantly. This can be due, for example, to differences in the access to financing among the industrial sites and to the intensity of regional / local competition. **There may also be regional disparities.** Some regions could take advantage of their location close to CCS zones or of available sources of Refuse-Derived Fuels (RDF). This would make some territories more attractive and thus secure (and potentially develop) the activity of cement manufacturing in the long term. Conversely, certain territories' dependency on cement manufacturing may make them more vulnerable in the case of a local slowdown in demand[16]. Under such circumstances, public authorities should pay particular attention to these territories and jobs associated to cement manufacturing.

Figure 9. Estimated change in the cement industry's total workforce in 2050 based on the Sectoral Transition Plan (reference scenario).



Note about the methodology:

* estimated on the basis of the elasticity between the labour factor and production over 2006-2018, and with a constant productivity (ADEME calculation based on data from ACOSS-Ursaff)

** estimate based on articles by Roussanaly et al., 2017 and De Lena et al., 2019

[14] Source: ACOSS-Ursaff

[15] Source: Infociments (2013) for the "indirect jobs" ratio and the estimated "downstream jobs" ratio based on ACOSS-Ursaff data. Note that the materials industry represents more than 65, 000 jobs, 35,000 of which are directly linked to concrete manufacturing.

[16] On average, the workforce of a cement plant represents 19% of the total number of jobs in the municipality where the site is located. For some municipalities, this rate is higher than 60%.

➜ Picture by VICAT/Créchy-Intérieur four

4.Towards more extreme scenario proposals to achieve the SNBC target

4.1 Two transitional contexts for achieving the SNBC's 81% reduction target

In the previous section, the spirit of the decarbonisation pathway was to extend and to improve existing production facilities through technology, working alongside cement manufacturers. Since this pathway fails to achieve the SNBC's industry target, two other more extreme scenarios that would meet it have been developed. The philosophy that has underpinned their development was to confront two diametrically opposed worlds.

Each proposed scenario is based on two mainstays: the level of production and the technological route.

Unlike the two extreme alternative scenarios, the reference scenario presented thus far was not guided by a commitment to achieving results, but rather an obligation of means. Indeed, the main purpose of developing this reference scenario was to model the existing decarbonisation levers and/or those with a clearly identified potential, on the basis of discussions and consultations with cement manufacturers and other stakeholders. This jointly conducted work was not conditioned by the need to achieve a specific reduction in the volume of CO_2 emissions by 2050.

The philosophy behind the two alternative "market shock" and "technological bet" scenarios is, however, to consider that the SNBC's 81% reduction target is achieved by 2050, regardless of the pathway. This basic assumption is similar to an obligation to achieve results conditioning the levers applied in each scenario. In this case, a major technological deployment is favoured in the extreme "technological bet" scenario, whereas a demand shock is simulated in the extreme "market shock" scenario. Table 2 summarises the main contextual elements charaterising each scenario. The comparison of these three "worlds" highlights substantially different decarbonisation means, as well as the consequences regarding the rate of emissions reduction and economic impacts.

Table 2. Summary of the main contextual elements of each scenario.

	Extreme "market shock" scenario	Reference scenario	Extreme "technological bet" scenario
Access to financing	★☆☆ Growth prospects in the construction market are low and private financing is therefore difficult to attract. Public support is more dedicated to support sites that are "in transition".	★★☆ Poor market prospects make it difficult to access financing for deploying innovative technologies. There is, however, public support, particularly for deploying CCS in specific zones.	★★★ Manufacturers benefit from significant investment and R&D subsidies, stimulating deployment of certain innovative technologies. This support is likely to reassure investors, who are more willing to grant financing.
Level of regulatory constraint	★★★ The target of Net Zero Soil Artificialisation from 2030 onwards triggers a tightening of urban planning and construction regulations across the country.	★★☆ The SNBC is not directly binding, but various incentive mechanisms implemented nationally influence local urban development plans in terms of new constructions.	★☆☆ The pace of construction is influenced by key market factors (price of building materials, relative price of land, etc.). The RE2020 regulation has only marginally affected the market share of building materials.
Change in demand for cement	★☆☆ Significant reduction in cement volumes due to the decline in construction activity. At the same time, demand for low-carbon cement is growing.	★★☆ Increase in the market share of wood under the RE2020 regulation despite a slowdown from 2030 onwards due to limited availability of wood. .	★★☆ Demand for concrete for infrastructure is increasing while demand for buildings is decreasing.
Decarbonisation technologies	★☆☆ The lack of resources means that companies resort to fuel substitution and lowering clinker content, which are the easiest and least capital-intensive levers to implement.	★★☆ Decarbonising the cement industry essentially involves fuel substitution, lower clinker content and deploying CCS where doing so is currently identified as being technically feasible.	★★★ In addition to fuel substitution and the reduction of clinker content, decarbonising the cement industry relies heavily on CCS, the development of alternative binders, and mineralisation.
Evolution of the industrial fleet	★★★ Clinker production is concentrated at the most efficient sites (dry process with precalciner) which can also incorporate a larger proportion of alternative fuels for a lower capital effort. The clinker is then transported to locations where cement can be prepared as close to the demand as possible. The other sites are converted into clinker grinding stations and for the production of calcined clay.	★☆☆ All the cement plants go through more or less the same transformation (upgrading, clinker content reduction, etc.), except those located in CCS areas. There is no specific restructuring of production facilities and all cement plants are subject to the same fluctuations in national demand.	★★★ Clinker production is concentrated in CCS areas and it is then transported to locations where cement can be prepared as close to the demand as possible. The other sites are converted into cement distribution platforms, for the production of calcined clay and for the production of new alternative binders.

4.2 Decarbonisation through technology: a transition guided by a ”technological bet”

In this extreme scenario, national cement production decreases by almost 10% with a greater focus on civil engineering, where demand is increasing. Annual emissions from the sector fall lower than the annual carbon budget set by the SNBC applied to the cement industry, just as CCS and mineralisation ramp up (Figure 10). Half of all cement plants are renovated and are upgraded with the Best Available Techniques (conversion to dry process with precalciner). In particular, cement plants located in CSC areas are also massified as part of the upgrading operation, which means that the kiln plant is substantially modified for higher energy efficiency and with an increase in production capacity. **The 81% reduction target is achieved by 2050 and even slightly exceeded, thanks to the sequestration of biogenic CO_2**. The permanent storage of biogenic CO_2 (in a geological storage for CCS or in the form of carbonated rock for mineralisation) acts as a carbon sink from a climate standpoint. The operation is equivalent to absorbing CO_2 from the atmosphere.

At first and in continuation with past trends, cement groups are pursuing their current decarbonisation measures, preferably through fuel switching and lowering the average clinker content which are the two simplest and cheapest levers to implement when the regulatory context and the market allow it. The production of calcined clay is motivated by investment support policies, by the looming end of free CO_2 allocation under the EU ETS scheme and by incentives for market players to use less carbon-intensive binders. From 2020 to 2030, decarbonisation will be mainly driven by downstream stakeholders (accompanied by cement manufacturers). They will adapt their construction practices so as to incorporate new products with lower clinker content (”demand is mutating”). Then, **from 2030 to 2050**, cement manufacturers will bear the effort for restructuring production facilities around this new demand which will act as a pivot (**”production is mutating”**). **Between 2020 and 2030**, cement companies will invest heavily in flash calcination kilns to produce calcined clay at their cement plants, to meet the demand while continuing to produce clinker.

Figure 10. Extreme ”technological bet” scenario – Decarbonisation pathway for the cement sector and associated abatement costs.

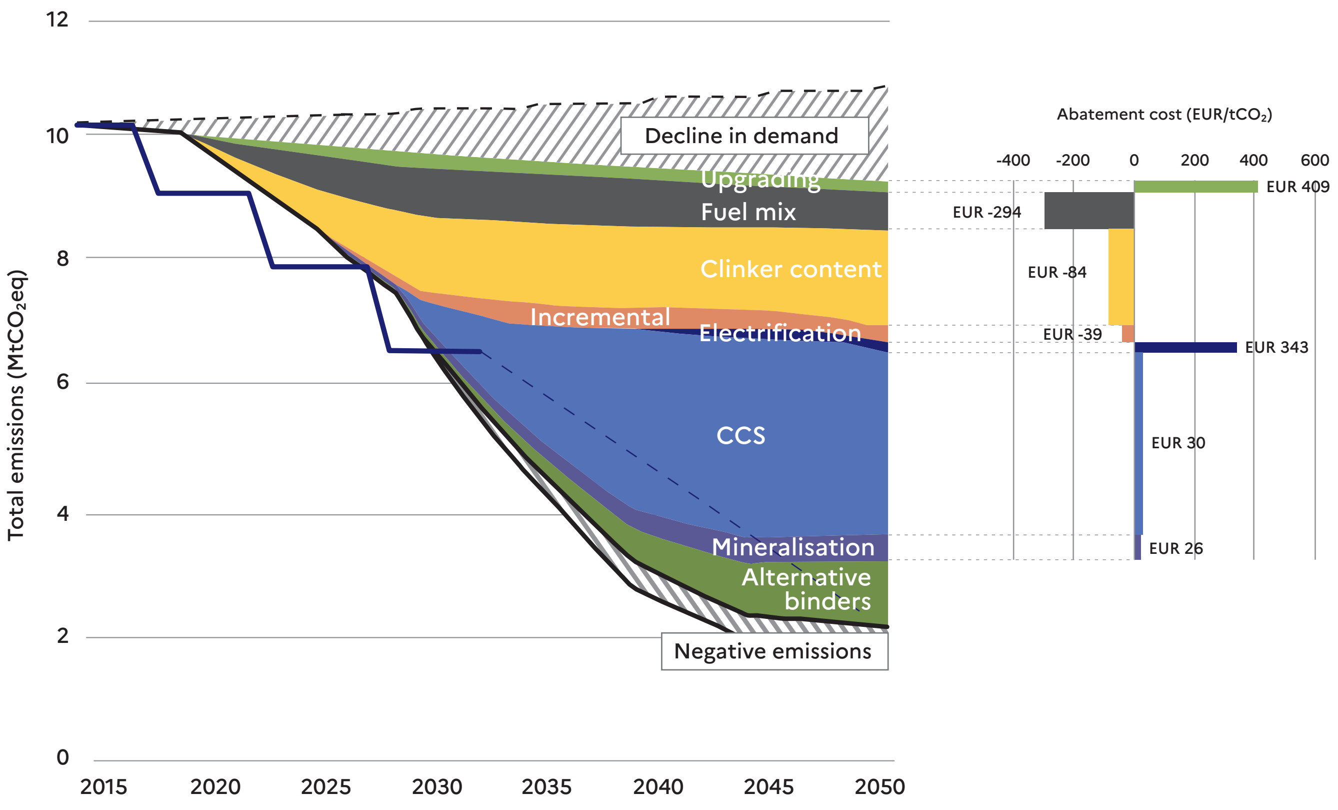


Figure 11. Extreme "technological bet" scenario – Investment forecast in the cement sector and evolution in emissions intensity (excluding capital cost).

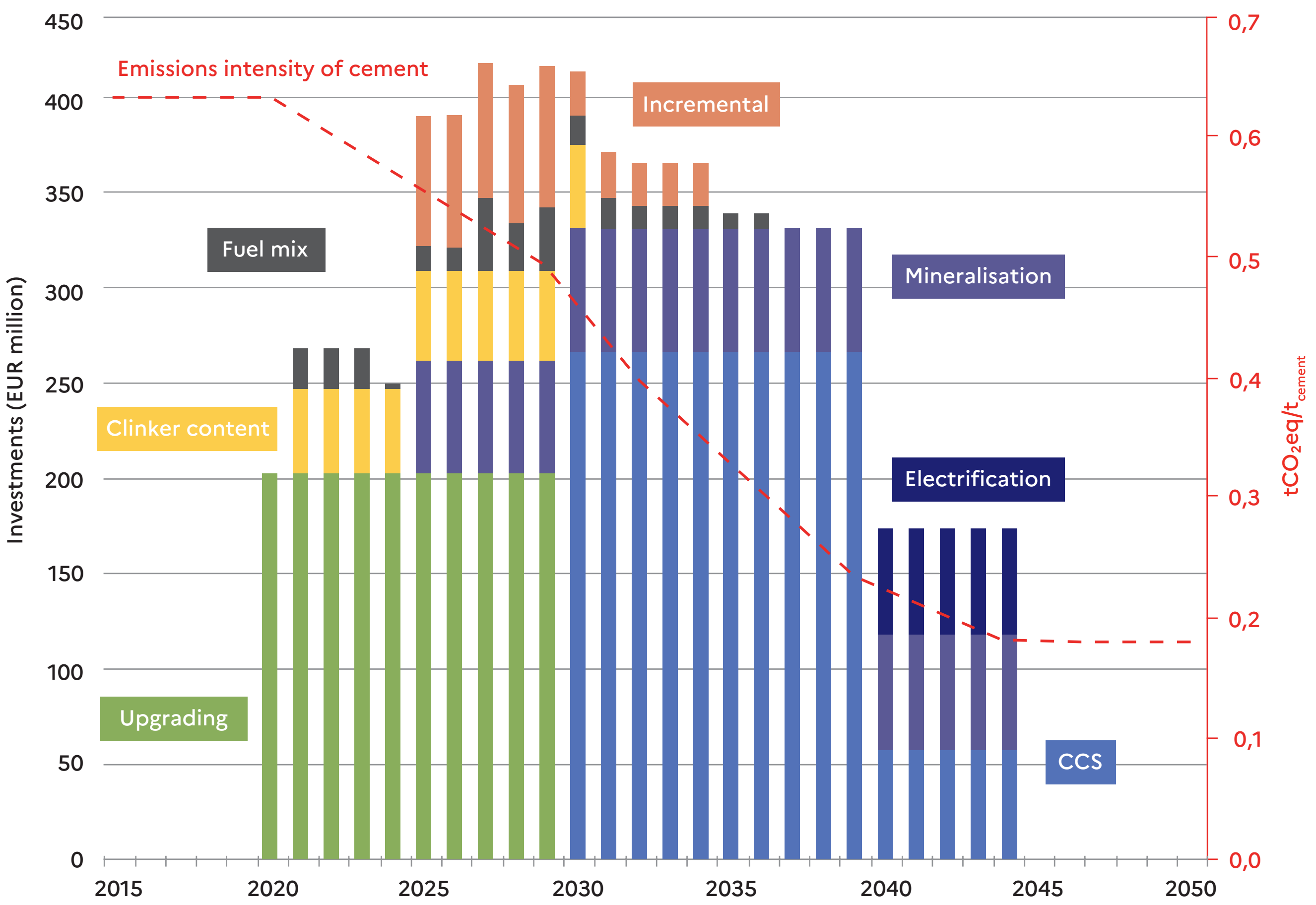


Figure 10 also shows that the cost of avoided CO_2 can be high, especially for electrification (EUR 343/tCO_2). In this case, this high abatement cost is justified by the concentration of CO_2 that electrification allows at the precalciner, meaning that the CO_2 can be captured with less effort at the outlet. **Electrification is therefore a technology to be considered alongside carbon capture.**

The total amount of investment required (Figure 11) is approximately EUR 7.7 billion of which a significant part is for the renovation and massification of strategic sites and the deployment of CCS and mineralisation. Furthermore, the projection of future investments highlights another challenge beside the total cost. To smooth out the investments over the next three decades as much as possible and to avoid sharp annual spikes (at the risk of stumbling on limits regarding maximum investment flows), this scenario cares to avoid overlaps between the investments related to upgrading in the first place, and those needed for CCS in the second place. In practice, **this means that it is essential for industrial players to rapidly identify (over the next decade) the strategic sites that will be upgraded, particularly in anticipation to the future deployment of CCS to be scheduled ahead**.

➜ Picture by CIMENTS CALCIA/Réparation

4.3 Decarbonisation through sobriety: the cement industry dealing with a market shock

In the extreme "market shock" scenario, of the 81% cut in CO_2 emissions by 2050 compared with 2015, 55% is the result of lower production – by far the main factor driving the decrease in emissions. The decrease in clinker content and the decarbonisation of the fuel mix, as well as the use of alkali-activated binders with slag account for the rest of the trajectory (Figure 12). In this scenario, the fall in demand is so rapid that by around 2030, the sector's annual emissions are below the carbon budget defined by the SNBC applied to the cement industry. By applying a linear carbon trajectory between 2033 and 2050, this annual advance on the budget in maintained until the 81% reduction target is reached in 2050.

In Figure 12, the impact of the drop in cement production on the sector's emissions is broken down into the main origins of the decline compared with a baseline demand scenario. Thus, the fall in demand for construction is the primary cause of production decline in 2050 (46%), followed by civil engineering (29%), optimisation of the use of cement (25%) and more marginally, the substitution of concrete for wood in remaining infrastructure (1%). Cement production is also slightly impacted by a very small difference in foreign trade in 2050 compared with 2015 (fewer imports), but this marginal effect has not been illustrated in the figure.

The volume of blast furnace slag required for binder production remains unchanged between 2015 and 2050 – about 1.5 Mt/year. However, in 2050, its use is divided between the production of conventional cement (more particularly CEM III, CEM V, CEM II/C-M and CEM VI) and the production of slag-activated binders. With a sharp decrease in cement production and a stagnation in steel production in parallel, the tension on the demand for blast furnace slag is gradually easing, thus freeing up the resource. The cement industry is taking advantage of this increased supply to offer alkali-activated binders made from 80% blast furnace slag. **Beyond the choice of this particular product, the use of alkali-activated**

Figure 12. Extreme "market shock" scenario – Decarbonisation pathway for the cement sector.

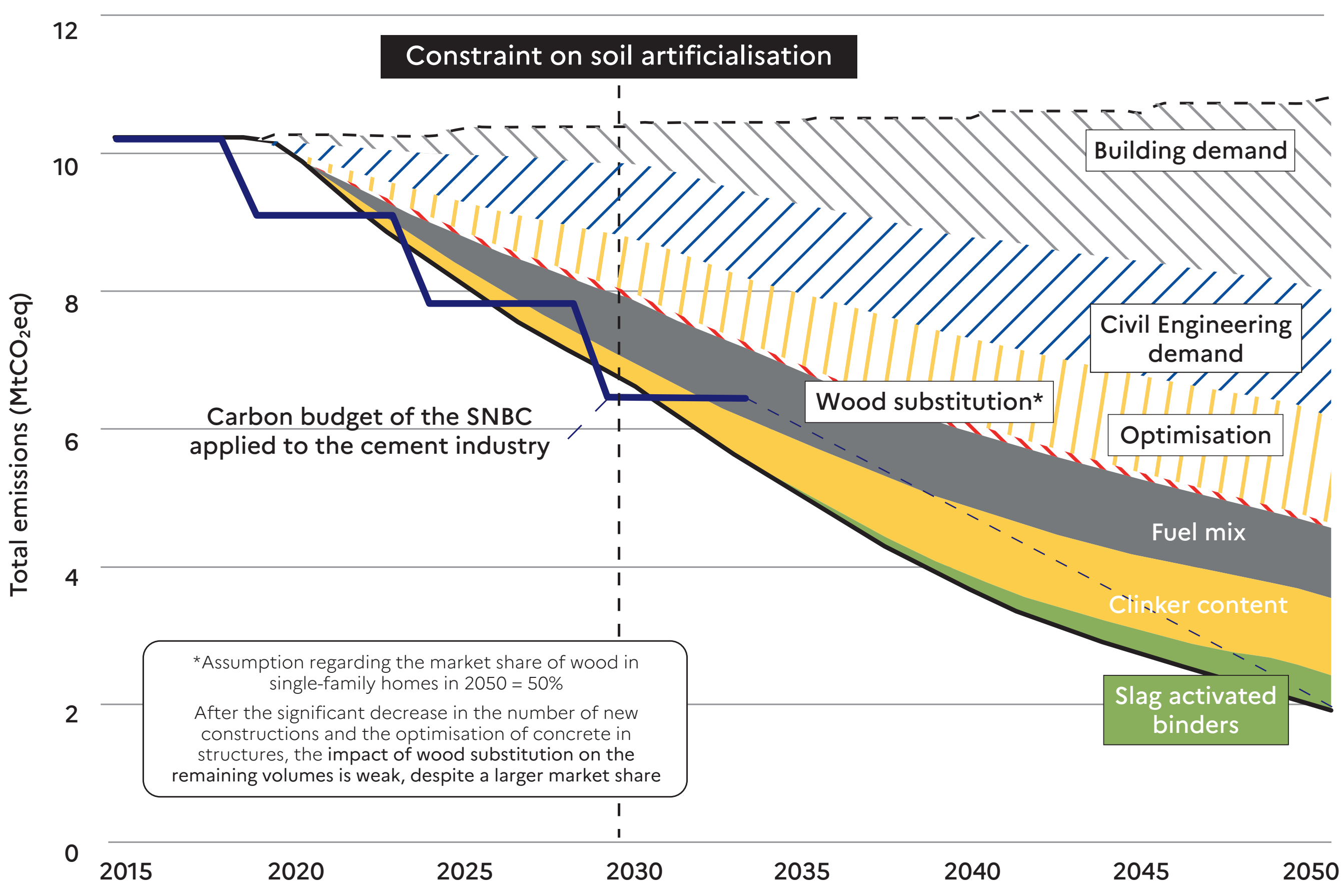
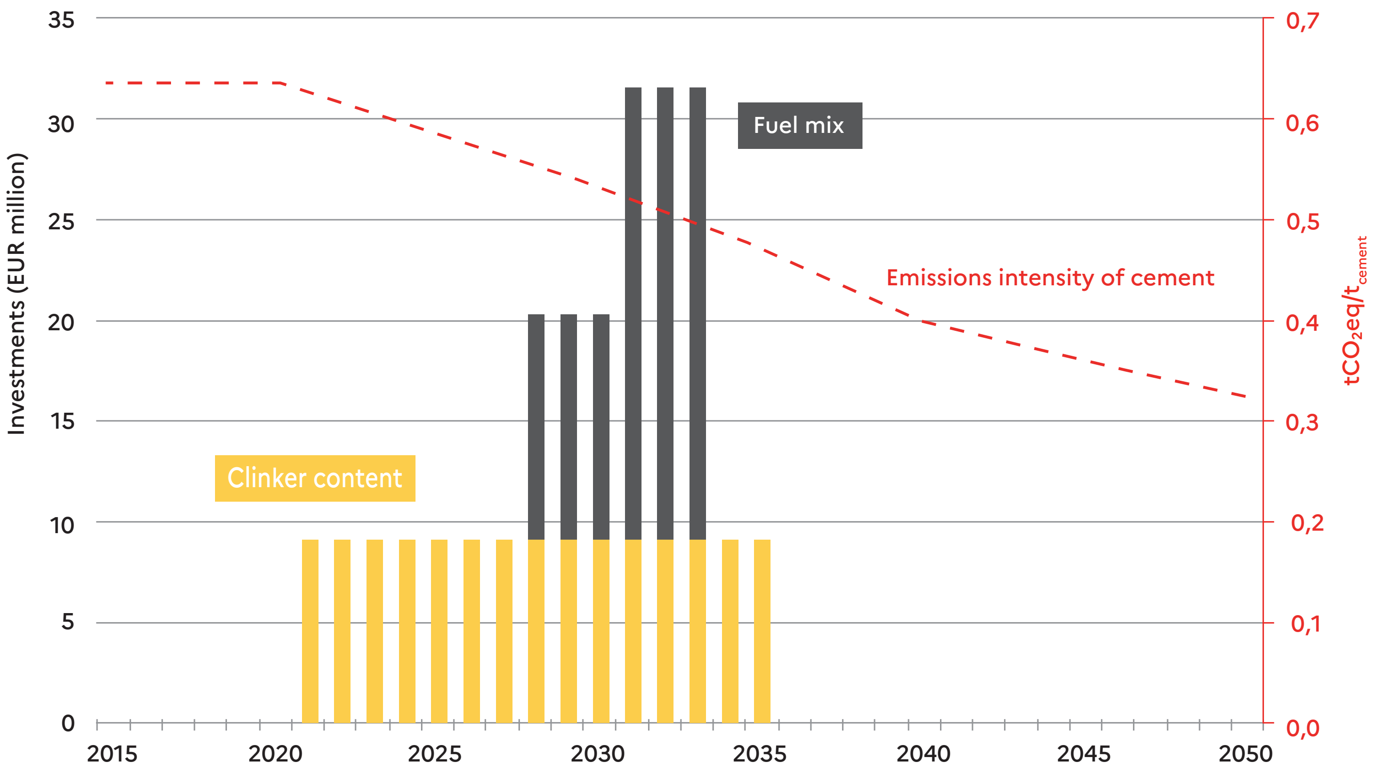


Figure 13. Extreme "market shock" scenario – Investment forecast in the cement sector and evolution in emissions intensity (excluding capital cost).



slag binders in this scenario mainly illustrates the fact that the supply tension affecting slag can potentially be loosened in this type of world[17]. The slag (which will have become more available) could be equally used to produce more CEM III/C, which can contain up to 95% blast furnace slag.

The total investment required amounts **EUR 240 million** over the period 2020-2050 (Figure 13). This is equivalent to less than two years' worth of average gross tangible investments for the cement, lime and plaster industry (NAF code 23.5). For the fuel mix, investments are needed to increase consumption capacity and for the preparation of alternative fuels (e.g. storage silos, conveyors, preparation workshops). Regarding clinker content, the global investment required was estimated based on the assumption that some of the rotary kilns making up the current clinker production capacity are converted for the production of calcined clay. In this case, capital expenditure was assumed to be EUR 10 million per conversion and the specific thermal consumption is 3.1 GJ/tonne of clay, as opposed to EUR 20 million and 2.7 GJ/tonne of clay respectively for a new flash calcination kiln (used in the other scenarios)[18]. As these are mature levers and technically mastered, investments are concentrated over the period 2020-2035 with an annual peak at around 2032. In this scenario, technological measures can be used to reduce the average carbon footprint of cement by about 55%.

A new environmental target of "Net Zero Soil Artificialisation" (ZAN) was officially adopted in France in 2018 as part of the French Biodiversity Plan. In the aftermath, an observatory was created in July 2019 to track progress. Reducing soil artificialisation has been made a priority because of the co-benefits it offers: fight against climate change (potential absorption of CO_2 and absence of emissions related to alternative use of soil), biodiversity refuge and mitigation of flood risks.

[17] More information about the interactions between the cement and steel sectors will be available in the full report on the cement STP, and in the research on the steel STP.

[18] S. Sanchez Berriel et al., "Assessing the environmental and economic potential of Limestone Calcined Clay Cement in Cuba", Journal of Cleaner Production, vol. 124, pp. 361-369, 2016. It should be noted that, to date, cement manufacturers have witnessed higher investments costs for the implementation of this type of technology.

5. Reference or more extreme scenarios: converging economic lessons, despite very different levels of investment

5.1 On average, cement is more expensive to produce and highly dependent on the price of CO_2

Due to the potential differences in the technological routes, both in terms of type of technology and the year of adoption at a given site, as well as the penetration rate across the industrial fleet, decarbonising the cement industry can have a multitude of potential impacts on the dynamics of production costs. In all three scenarios, **assumptions on the evolution of energy and CO_2 prices between 2020 and 2050 have been taken** (Figure 14). The aim is not to predict any price increase, since they are subject to many uncertainties, but rather to reflect the impact of different OPEX values (i.e. energy OPEX and CO_2 OPEX) in the cost of cement, which depend on unit prices and how energy- and CO_2-intensive production is. Regarding CO_2 more specifically, although cement manufacturers have been getting free allocation on the EU ETS market since it was first introduced, **a gradual phase-out of these free allowances from 2025 to 2030 has been modelled in the three scenarios[19].** The European Union and France have recently raised their ambition regarding climate targets which provides additional support for a future significant increase in the price of CO_2, in the order of EUR 181/tCO_2 in 2050. **The carbon price trajectory from the Banque de France in its "orderly transition" scenario has been chosen as an input for the model[20].** The same source was used for the price of fossil energy, while a study conducted by ADEME on the power mix was used to compute a trajectory for the increase in the price of electricity between today and 2050[21].

Figure 14: Assumptions regarding the trajectories for CO_2 and energy prices.

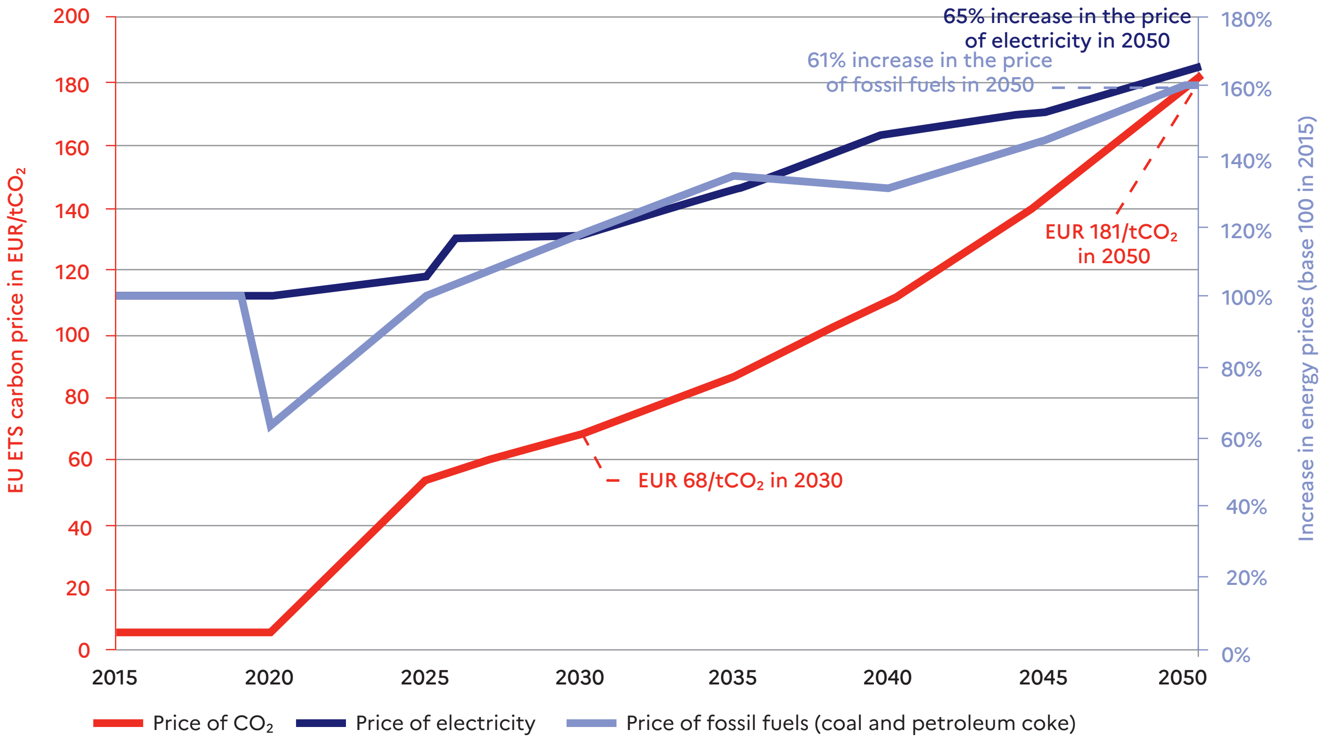


Figure 15. Evolution of the production cost of cement between 2015 and 2050 (base 100 in 2015)

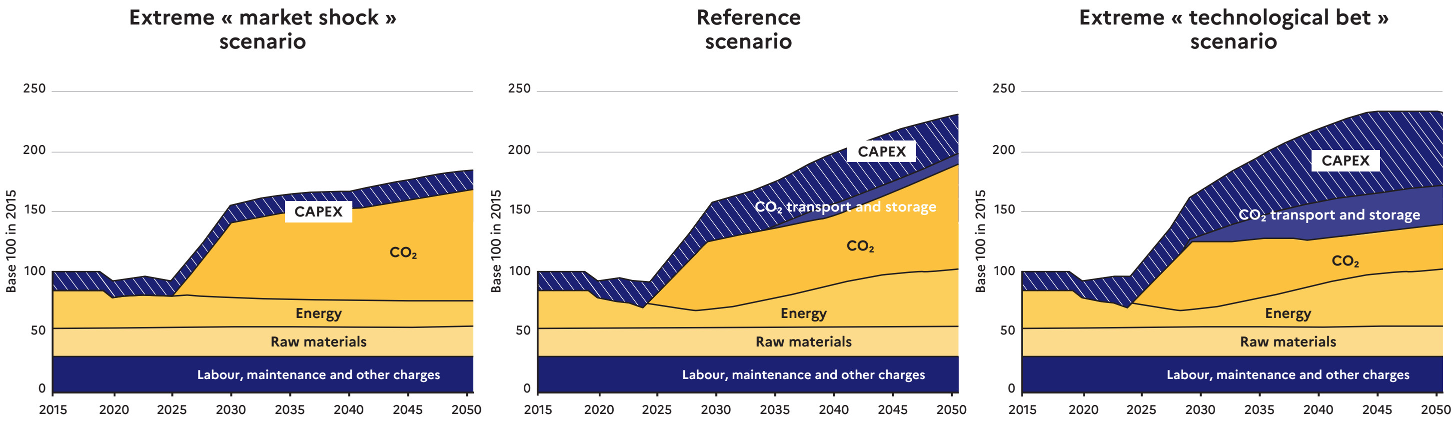


Figure 15 shows the impact of the transition on average production costs for the French cement industry by 2050, according to the various scenarios. In addition to capital expenditure, the increase in the carbon price up to EUR 181/tCO_2 in 2050 will lead to a **production cost increase in all scenarios. Without any investment in decarbonisation, the cost of inaction would triple the cost of cement production, whereas investing in decarbonisation would "only" double it.**

Achieving the 81% emissions reduction target by 2050 compared with 2015 levels in the alternative extreme scenarios does not seem to generate higher production costs than in the reference scenario – which, besides, only results in a 54% cut. **Achieving the SNBC target – whether through massive deployment of technologies or a significant drop in demand – will increase the unit cost of production by 130% and 85% respectively, compared with 130% for the reference scenario.** Observing the cost structure and when taking into account an increasing price of CO_2 and the gradual phase-out of free allowances, carbon becomes a major element in the production cost of cement in the "market shock" scenario (Figure 15). Although the production volume is greatly reduced, the CO_2 intensity remains high and manufacturers still have to pay for this CO_2 through the purchase of CO_2 allowances on the EU ETS market. Nevertheless, low production levels in this context enable manufacturers to reduce their energy expenditure (in absolute terms), while CAPEX spending only increases very slightly unlike in the "technological bet" scenario. Indeed, CO_2 intensity is significantly reduced in this latter scenario by deploying innovative technologies. However, the fixed costs of these technologies are high particularly for CCS which also entails new costs related to the energy penalty and transport and storage, in addition to CAPEX. **In the "market shock" scenario, CAPEX amortisation only increases 19% by 2050, whereas it is multiplied by 4 in a decarbonisation scenario driven by technology.**

×2

Order of magnitude of the impact of the transition scenarios on the production cost

×3

Order of magnitude of the impact of the price of CO_2 on the production cost without investment in decarbonisation

[19] This option has been put forwad on several occasions by the European authorities during the discussions about the Carbon Border Adjustment Mechanism. French authorities are also in favour of a gradual phase-out of free allowances, in the event of a Carbon Border Adjustment Mechanism (International Conference on the Carbon Border Adjustment Mechanism organised by France March 23, 2021).

[20] ACPR, "Climate Risk Analysis and Supervision - Key Scenarios and Assumptions" 2020.

[21] ADEME, "Trajectories of the electricity mix, 2020-2060", 2019. This trajectory does not take into account the impact of investments on network infrastructure.

5.2 ...while the impact on a building's final price remains limited

When the economic shockwave spreads along the entire value chain, the increase in the production cost of cement can have a knock-on effect on a building's final price. Each economic stakeholder passes the impact of this increase (to a greater or lesser degree) onto the price of the product they sell. Although the increase in the price of raw materials has an effect on the final selling price, there are other important factors to consider such as the sales policy of the company, the strategic behaviour of competitors or changes in the price of potential substitutes to cement and concrete.

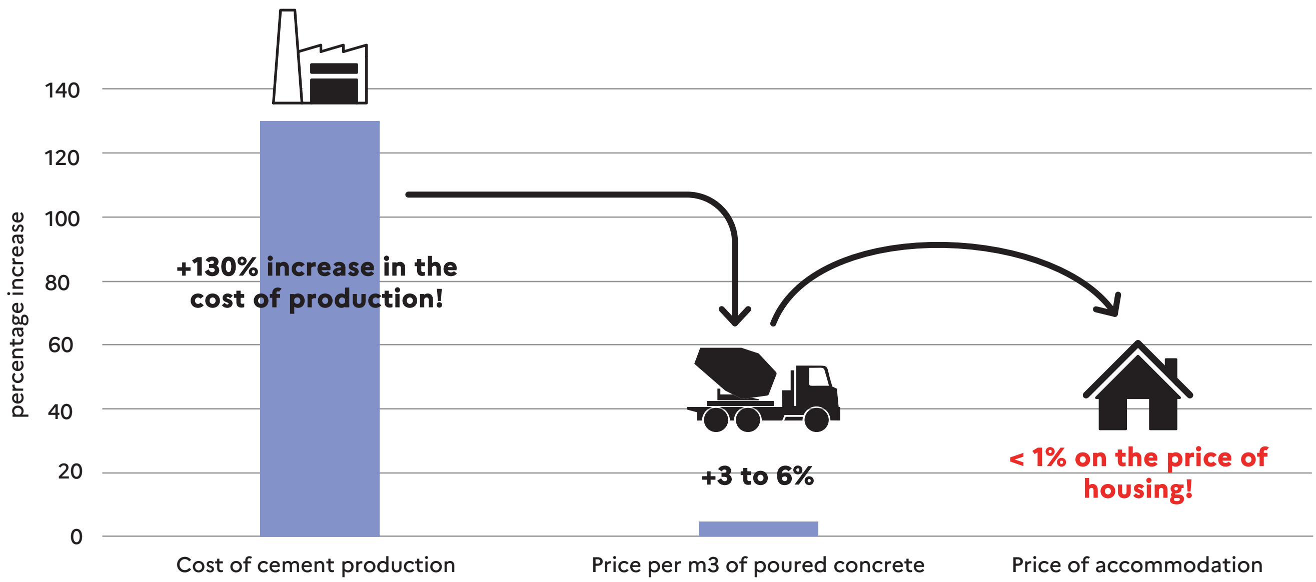
However, since these factors are difficult to grasp, a "sectoral" approach has been adopted based on public data available in the literature and a rationale that all other things stay equal. The values calculated are therefore only intended to give an order of magnitude of the effect of the cement sector's transition on the final price of a construction, regardless of possible changes in other explanatory variables (such as the price of sand, the cost of labour, etc.). Figure 16 shows that **doubling the unit cost of cement production – as modelled for the reference scenario and the "technological bet" scenario – has little effect on the final price of a house.** This is due to the low weighting of the cost of cement compared with other cost items in concrete production, and ultimately in construction.

In order to measure the distribution of the increase in the production cost of cement across the value chain, given the importance of the potential investments to be made, it was decided to pass on all the variation in production cost to stakeholders downstream, and not just the variable cost, as shown below:

$$\Delta P_{structure} = \Delta \textit{Production cost}_{cem} \times CPT \times S_{concrete} \times S_{structure}$$

with $\Delta P_{structure}$ being the variation in building cost, $\Delta \textit{Production cost}_{cem}$ being the variation in cement production cost as measured for each transition scenario, CPT being the cost pass-through of the cement industry taken from a 2015 European Commission study[23], $S_{concrete}$ being the share of the cost of cement in the overall price of concrete as calculated by ADEME based on the unit prices of other raw materials, then the mass distribution of concrete components and the cost structure for one cubic metre of poured concrete indicated in a study produced by the Ifpeb (2020)[24]. Finally, $S_{structure}$ is the share of the cost of concrete in the building estimated based on a 2017 article by Rootzén and Jonhsson[25].

Figure 16. Effect of the increase in the cost of cement production on the price of a house (example of the reference scenario)[22].



[22] These estimates do not take into account the possible pricing strategies adopted by stakeholders across the sector and competition from other materials. They are based on public literature, the only data available. For some manufacturers, the impact on the final price of a home would be higher.

[23] European Commission, "Ex-post investigation of cost pass-through in the EU ETS: an analysis for six sectors", 2015. Cost Pass-through: passing on the increase in production costs to the cement sales price.

[24] Ifpeb, "Concrete sector brief – key messages", 2020

[25] Rootzén and Jonhsson, "Managing the costs of CO_2 abatement in the cement industry" , Climate Policy, vol. 17, pp.781-800, 2017

6. Modelling methodology

6.1 Modelling of the current French cement industry

Based on the current structure of the cement sector, mostly represented by three major clinker manufacturing processes, three reference plants have been modelled (Figure 17). These virtual plants illustrate the three most commonly used cement manufacturing processes in France: the **dry process with precalciner, the dry process without precalciner** and the **semi-dry process.**

The construction of the reference plants was based on data from French cement manufacturers (source: energy audits and site energy performance plans).

Each reference plant is described by its equipment, major phases of cement preparation, specific energy consumption (thermal and electric) and fuel mix.

The third bar chart in Figure 17 shows the French cement sector as modelled in a first approximation. The cement plant's emissions and total energy consumption can be deduced from specific energy consumption and GHG emissions and total clinker production: the values thus obtained are relatively close to the real values for 2015, the base year chosen for the modelling (Table 3). This means that the representation of the French cement industry can be validated.

➜ Picture by EQIOM/Carrière de Bayel

Figure 17. Number of cement plants and emissions from clinker production by manufacturing process in 2015.

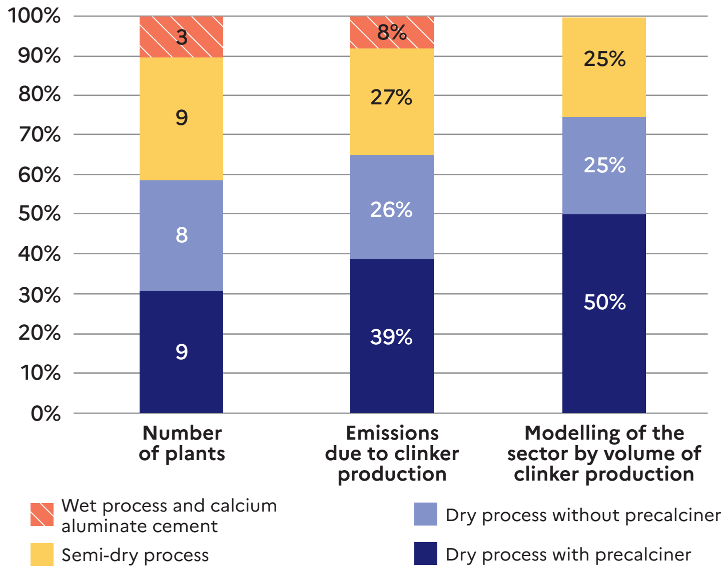


Table 3. Comparison of actual and modelled values of the French cement industry.

	Modelling	2015 values[26]	% difference
Clinker production (Mt)	12.5	12.5	0%
Emissions due to clinker production ($MtCO_2eq$)	10.2	10.3	1%
Total thermal energy consumption (GWht)	13 190	13 110	1%
Total electricity consumption (GWhe)	1 960	1 810	8%

[26]Sources: SFIC, GEREP and EU-ETS data.

6.2 Building a decarbonisation pathway

Decarbonisation technologies have been extensively researched in the literature to quantify their impacts on the reference plants in the modelling. The next step was to create a decarbonisation pathway in line with the philosophy underpinning the scenario by formulating assumptions on the temporal deployment of technological levers. **The detailed construction of the reference scenario is presented in this section as an example,** but this process was identical for the other scenarios. The full set of modelling assumptions will be provided in the final STP cement report.

Thus, in the reference scenario, an assumption on the temporal deployment of each decarbonisation lever has been made. These assumptions are summarised in Table 4. Except for CCS, where a maximum penetration rate of 20% has been assumed, and for upgrading, which is only applied to dry process plants without a precalciner and to semi-dry process plants[27], all the other decarbonisation levers are applied similarly to all the emissions of the French cement industry, and these would be fully deployed before 2050.

This is why the reference scenario can be described as a technological extension of existing production facilities.

Some general considerations regarding the choice of decarbonisation levers and their temporal deployment assumptions, which result from bibliographical research and discussions with manufacturers, should be highlighted. The decarbonisation levers presented can be considered as mature initiatives, because they have already been used by the profession for some time or because there is relatively good confidence in their technically viability in the next 30 years. The hypotheses regarding the technologies and their penetration rate have been chosen according the general spirit: "the faster, the better". In particular, great importance has been given to the reduction of the clinker-to-cement ratio which comes with the development of new products. To align the pathway as closely as possible with the 2030 emissions reduction targets as a crossing point (as formulated in the SNBC or in the new European roadmap), all the levers considered technically mature or close to maturity have been concentrated on the 2020-2030 period.

Table 4: Reference scenario - Deployment of decarbonisation levers across the French cement industry.

Lever	Description	2015	2020	2025	2030	2035	2040	2045	2050
Upgrading	Plants renovated to a dry process with precalciner close to BAT performance level		50%			100%			
Fuel mix	Average substitution rate of **95% of which 45% biomass (SFIC target),** reached in 2035		Average substitution rate ≈ 40%				Average substitution rate ≈ 95%		
Clinker content	Decrease in the average clinker-to-cement ratio from 78% to **66% in 2030 and 58% in 2050.**		Clinker content: 78%			Clinker content: 66%			Clinker content: 58%
Incremental	Range of technologies, "small" improvements in energy efficiency and specific emissions		0%	100%					
CCS	Start in 2035 over a 5-year deployment period, **maximum penetration rate of 20%.**					0%	20%		

➜ Picture by VICAT/Brésil-CIPLAN-Cimenterie

First, there is a major difference in the technological pathway depending on whether or not the plant is already operating on a dry process with precalciner: it is assumed in the modelling that only dry process plants without precalciner and semi-dry process plants are upgraded and converted to a dry process with precalciner, which corresponds to the standard of Best Available Techniques for a new cement plant. Along with CCS, upgrading is the most capital-intensive of all decarbonisation levers but delivers a double benefit: the conversion directly improves thermal energy efficiency by around 20% on average and unlocks the possibility for higher substitution rates, and therefore increased decarbonisation of the fuel mix. As dry process plants with precalciner can already integrate a significant fraction of substitution fuels into the thermal mix and are already relatively efficient compared with the benchmark from Best Available Techniques, they are not renovated in the proposed pathway. All other decarbonisation levers are applied in the same way, regardless of the reference plant.

The reduction in the average clinker-to-cement ratio from 78% to 66% in 2030 represents a more ambitious target than the one currently proposed by the industry. This will require to support construction players in adopting new products or even changing certain practices and regulations (national and European). To spark such a transformation, it is likely that the content of public tenders should also be modified and studies to characterise clay deposits of a sufficiently good quality will be necessary.

Nevertheless, this target is technically feasible and more and more low-carbon products seem close to market readiness.

A clinker-to-cement ratio of 66% is also the target set by the IEA for Europe in its 2DS scenario (2 Degrees Scenario)[28]. After 2030, the downward trend continues until it reaches 58% in 2050. However, the rate of decline is less pronounced between 2030 and 2050 to illustrate the fact that, like energy efficiency, the main gains are more easily achieved at the beginning of the transformation. When looking at the most common types of cement, it seems technically complicated at the moment to reduce clinker content to well below 50% in formulations without resorting to large proportions of blast furnace slag. Clinker is the element that gives its hydraulic properties to ordinary cement, so some quantity will always be required in cement to fulfill its "binding" role.

[27] ADEME's Opinion on Carbon Capture and Storage in France:
https://www.ademe.fr/avis-lademe-captage-stockage-geologique-co2-csc-france

[28] IEA (2018), Technology Roadmap - Low-Carbon Transition in the Cement Industry, IEA, Paris

6.3 Focus on the critical cost of CCS for decarbonising a plant

The results presented in each scenario have been obtained by modelling three reference plants representing the three most commonly used clinker manufacturing processes in France (dry process with precalciner, dry process without precalciner and semi-dry process). Decarbonising the cement industry is therefore equivalent to extrapolating and smoothing out the results obtained for each of these reference plants. Table 5 summarises the main results obtained for the three reference plants in a situation with CCS and where the CO_2 would be transported and shipped for offshore storage from a hypothetical CCS hub similar to the future one envisioned in Dunkerque.

The additional investment cost for CCS is only for the "capture" component of the technology and does not include the capital expenditure for CO_2 transport and storage. The cost for the capture technology was estimated at around EUR 60/tCO_2 in the modelling. The cost of CO_2 transport and storage has been modelled on the basis of estimates provided in an analysis from ADEME about CCS for the Hauts-de-France (Dunkerque hub), Normandie (Le Havre hub) and Nouvelle-Aquitaine regions (onshore storage by pipeline). For the cement plants connected to the Fos-sur-Mer CCS hub in the extreme "technological bet" scenario, the cost of CO_2 transport and storage has been assumed equal to that of the Dunkerque hub, assuming offshore storage in the Mediterranean Sea by ship. From the perspective of cement plants, this cost appears as an OPEX item, which means in practice that the industry is paying an external company for a network service. Hence, even though transport and storage require material investment, they do not appear in the investment of the cement industry. The costs used in the modelling range between EUR 50 and EUR 60/tCO_2 for offshore storage by ship and EUR 18/tCO_2 for onshore storage by pipeline in Nouvelle-Aquitaine.

In the case of offshore storage, capture would thus only account for around half of what is needed for a complete CCS chain. These estimates should be taken with caution: the cost of CO_2 transport and storage is highly dependent on the distance between the emitter and the sink, the type of environment in which the transport infrastructure is deployed (onshore or offshore, flat or mountainous, urban or rural, etc.) and the annual volume of emissions that passes through it. For example, for a pipe with a fixed capacity, the final cost will be lower when greater volumes of CO_2 are transported annually through this pipe, hence the importance of pooling and optimising the infrastructure across several emitting sites to achieve economies of scale.

Figure 18. Example of the evolution in production cost in a technological pathway with CCS for a semi-dry process plant.

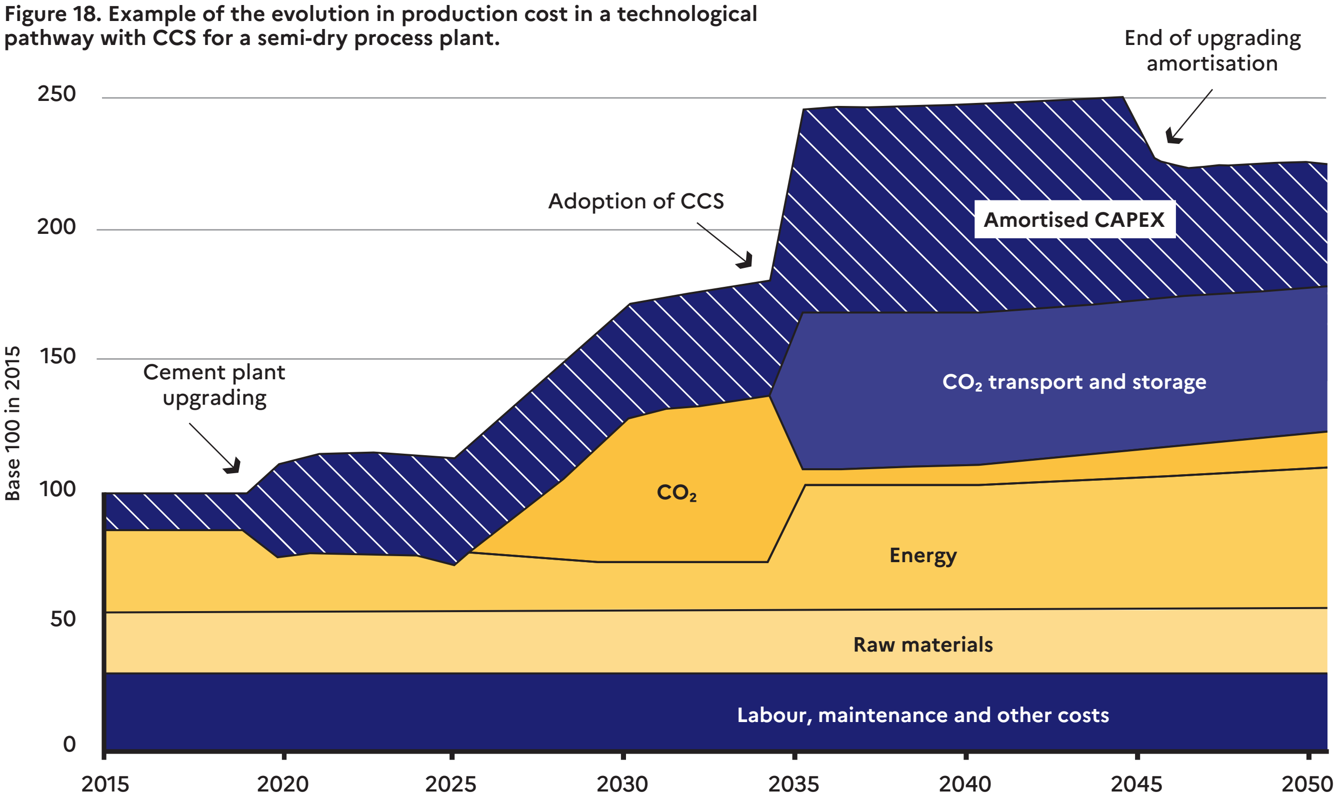


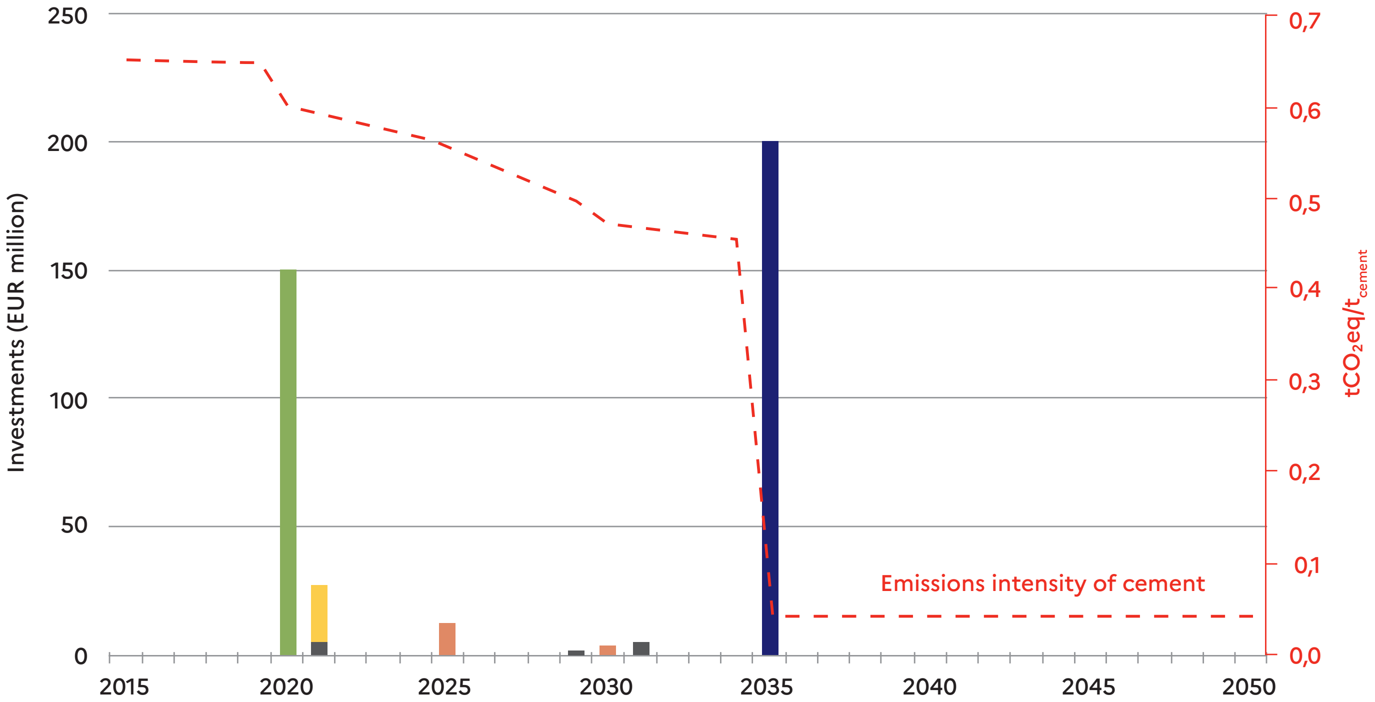
Table 5. Main results obtained for each reference plant with CCS for offshore transport and storage by ship.

Reference plant	% decarbonisation between 2015 and 2050	Total investment / plant	Share of upgrading	Share of CCS	% increase in production cost
Dry process with precalciner	-94%	≈ EUR 245 million	0%	≈ 80%	≈ +140%
Dry process without precalciner	-94%	≈ EUR 405 million	≈ 35%	≈ 50%	≈ +140%
Semi-dry process	-94%	≈ EUR 400 million	≈ 35%	≈ 50%	≈ +150%

After cross-referencing various bibliographical sources, the investment in capture technology has been estimated to EUR 200 million for a cement plant which makes it the most capital-intensive solution before upgrading when the plant is eligible to CCS **(see Figure 18 and Figure 19 showing the effects of the decarbonisation pathway on the semi-dry process reference plant)**. Note that the following figures represent the specific investments and emissions for a cement plant that is being upgraded to a dry process with precalciner. The cement plant has adopted a proactive approach which is why investments are focused on the period 2020-2035: compared with Table 4, the decarbonisation levers are deployed as early as possible (e.g. upgrading in 2020, incremental technologies in 2025, CCS in 2035, etc.). A cement plant with a less proactive approach could have more staggered investments (e.g. upgrading in 2035, incremental in 2030, CCS in 2045). This would focus investments over the 2035-2045 period, reducing emissions later, but the total amount of investment would remain unchanged.

In Figure 18, the upgrading operation can be detected in the evolution of production cost: it creates a staircase profile in 2020 due to the amortised CAPEX. In 2025, the cost of CO_2 appears in the production cost, corresponding to the phase-out of free allowances and the increase in the price of CO_2 paid by manufacturers under the EU ETS scheme. Nevertheless, this cost quickly declines from 2035 onwards with the deployment of CCS at the plant. This instantly reduces emissions by nearly 95%. Thereafter, the cost of CO_2 in the cost structure is replaced by new costs induced by CCS: (1) new material investments to be amortised, (2) an operating cost for CO_2 transport and storage and (3) an energy penalty to be covered in a context where energy prices (electricity and fossil fuels) are increasing.

Figure 19. Investment forecast for a semi-dry process plant and evolution in emissions intensity (excluding capital cost).



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Abbreviations and acronyms

ADEME - French Agency for Ecological Transition
NHIW - Non-Hazardous Industrial Waste
IEA - International Energy Agency
ECRA - European Cement Research Academy
BAU - Business As Usual
BATs - Best Available Techniques
CE - Civil Engineering
STP - Sectoral Transition Plan
CCS - Carbon Capture and Storage
SNBC - Stratégie Nationale Bas Carbone
(France's national low-carbon strategy)
RDF - Refuse-Derived Fuels
RON - Roads and Other Networks

ADEME IN BREF

At ADEME – the Agency for Ecological Transition – we are firmly committed to combating climate change and degradation of resources.

On all fronts, we mobilise citizens, economic players, and regions, empowering them to move towards a resource-efficient, carbon-free, fairer, and more harmonious society.

In all areas – energy, air, circular economy, food, waste, soils, etc., we advise, facilitate and help finance many projects, from research through to solution-sharing.

At all levels, we put our expertise and prospective capabilities at the service of public policy.

ADEME is a public establishment under the joint oversight of the French Ministry of the Ecological and Solidarity Transition and the French Ministry of Higher Education, Research and Innovation.

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KEYS FOR ACTION
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EXPERTISE
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RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
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ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

EXPERTISES

CEMENT

Summary report

The cement industry faces major technological and economic challenges in order to achieve the decarbonisation targets set under the National low-carbon strategy (SNBC) – an 81% reduction in greenhouse gas emissions in 2050 compared with 2015 for the French industry as a whole. The cement manufacturing process is energy intensive and generates hard-to-abate GHG emissions. With the modelling carried out, and based on the technologies identified, a 54% reduction in greenhouse gas emissions can be achieved at best. Other solutions must therefore emerge if the sector is to meet the 81% decarbonisation target set under the SNBC for industry, especially for the period 2030-2050. Decarbonisation will require massive investments in the production tool, innovation and regional infrastructure. To maintain a decarbonisation trajectory in line with the Paris Agreements, regulation must accompany the changes in the production plants and provide a medium-term strategy to ensure the sustainability of longer-term investments and amplify the participation of financial institutions.

The Finance ClimAct project contributes to the implementation of France's National Low Carbon Strategy and the European Union's Sustainable Finance Action Plan. It aims to develop tools, methods and new knowledge to enable (1) savers to integrate environmental objectives into their investment choices, and (2) financial institutions and their supervisors to integrate climate issues into their decision-making processes and align financial flows with energy and climate objectives.

The consortium, coordinated by the French Agency for Ecological Transition (ADEME), also includes the French Ministry of Ecological Transition, the French Financial Markets Authority (AMF), the French Prudential Control and Resolution Authority (ACPR), the 2° Investing Initiative, the Institute for Climate Economics (I4CE), Finance for Tomorrow and GreenFlex.

Finance ClimAct is a first-of-its-kind programme with a total budget of EUR 18 million and EUR 10 million in funding from the European Commission.

Duration: 2019-2024

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