« Decarbonizing energy intensive industries 2021: country study France »

Project for the European Trade Union Institute (ETUI)

Final report
Introduction

METHODOLOGY, OBJECTIVES AND CONSTRAINTS

It is already more than visible that climate change and environmental degradation are affecting ecosystems, economic sectors and social conditions around the world. After long debates and little decisive action, the international Paris Agreement at the end of 2015 was a milestone in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to carry out actions and measures to combat climate change together. Its goal was to limit global warming to well below 2 (preferable to 1.5 degrees Celsius), compared to pre-industrial levels. To achieve this, all signatory countries aim to reduce their greenhouse gas emissions (GHG emissions) as soon as possible to reach climate neutrality.

Europe’s commitment to these objectives is embodied in the European Green Deal\(^1\) which aims to transform the EU into a modern, resource-efficient and competitive economy, ensuring:

- No net emissions of GHG by 2050,
- Economic growth decoupled from resource use, and
- No person and no place left behind.

The European Green Deal Investment Plan (EGDIP)\(^2\) is the investment pillar of the Green Deal and has three main objectives:

- To increase funding to support sustainable investments over the next decade through the EU budget and associated instruments, such as Invest EU,
- To create an enabling framework for private investors and public sector to facilitate sustainable investments,
- To provide support to public administrations and project promoters in identifying, structuring and executing sustainable projects.

The EGDIP will mobilise at least €1 trillion. Part of the plan, the Just Transition Mechanism, will be targeted to a fair and just green transition, mobilising at least €100 bn investment over 2021-2027 period, to support workers and citizens of the regions most impacted by the transition.

Within the European Commission, the High-Level expert Group on energy-intensive industries, composed of Member States, industry and civil society, is contributing to achieve climate objectives. In 2019 the expert group published the “Masterplan for a Competitive Transformation of EU Energy-intensive Industries enabling a Climate-neutral, Circular Economy

\(^1\) https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
by 2050”, being aware of the important role of Energy-intensive Industries (EII) in the transition towards climate-neutrality. The EII constitute the backbone of key strategic value chains of the European economy and society. According to EU data, these companies reduced their emissions by 36% between 1990 and 2015, accounting for 28% of emissions reduction in the entire EU economy while representing around 15% of total EU GHG emissions (excluding LULUCF). Several studies indicate these reductions can be taken further by incorporating circular economy and process efficiency strategies into industrial activities. EII are aware of this and are already working on concrete projects. This transition must deal with two major challenges:

- Maintaining industrial competitiveness in an environment of strong international competition, and
- Ensuring a transition of the skills of the workforce that guarantees its continuity and minimises impacts on employment.

The present report aims at addressing the main issues at stake regarding decarbonisation, its impact on employment, competences and skills of workers for the EII and the measures that could be implemented in order to minimize these impacts either from a national or sectoral point of view as well as from companies’ side.

The perimeter of the study covers 4 critical sectors in Europe that encompass some of the most energy-intensive industries in France: Steel, Chemicals, Cement and Non-ferrous metals.

The contents are drafted considering limitations in terms of data availability and timeliness, public available information and the state of progress of plans and programmes relating to the decarbonisation of the EII in France in the different sectors concerned by this case study.

Although the most possible reliable sources have been consulted, some of the data may be challenged due to the heterogeneity and lack of freshness of some sources from public administration, statistics institutions and employers’ organisations as well as due to the heterogeneous level of information provided by the companies with regards to their climate policies or decarbonisation strategies.

A second limitation appears when addressing the mapping of the EII sectors as long as activities inside each sector are multiple and cover a wide range of productions; obviously not every plant covered by this first and almost exhaustive list can be defined as energy-intensive but a global

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4 Land use, land-use change, and forestry.

5 Regarding the chemical sector and according to the main French chemical industry employers’ organisation (Francechimie), we do find several subsectors such as inorganic chemistry, surfactants and cosmetics, basic organic chemistry, water treatment, plant chemistry, compressed gases, plastics, explosives and pyrotechnics, plant protection, detergents and industrial hygiene products, aromatic products, synthetic chemistry and biochemistry, fertilisers). Inside the non-ferrous metals sector and apart from aluminium, whose production entails the highest electricity costs, there are minerals such as copper, graphite, nickel, cobalt, lithium or manganese, whose production has increased to address the high demand of electric batteries for new mobility and consumer electronics. The steel sector encompasses upstream crude steel production, by blast furnace or electric arc furnace, and a wide range of downstream transformation activities. Finally, the cement sector includes different productions such as cement, clinker, aggregates, lime, ready-mix concrete, etc.
vision by company has been taken to address the general issue of decarbonisation and the companies’ strategies.

Moreover, some of the European mechanisms that aim to counterbalance unfair competition (CBAM\textsuperscript{6}) are nowadays under discussion and therefore their real impact on industry and employment trends are still uncertain.

These limitations having been highlighted, the present research aims to present the most accurate overview of the current situation of the French EII, the current and future challenges of the sector, the national, sectoral and corporate strategies towards decarbonization and, as far as possible, the challenges in terms of employment and skills.

1. Mapping of energy-intensive industries

1.1. LEGAL DEFINITION OF ELECTRO-INTENSIVE INDUSTRY\textsuperscript{7}

In 2005 and for the first time, a specific legal status for electro-intensive companies in France was introduced by law with the aim of facilitating access to electricity and financing the high consumption required by these industries.

The characteristics of the EII status have changed over the years and it is now regulated by Art. 351-1 of the Energy Code\textsuperscript{8}, which establishes three criteria for a company to be considered electro-intensive (EII) or hyper electro-intensive (HEII):

\begin{table}[H]
\centering
\begin{tabular}{|c|c|}
\hline
Product & Estimations of electricity consumption by produccion (MWh/t) \tabularnewline
\hline
Aluminium & 15 \tabularnewline
Ferroalloys & 6 \tabularnewline
Zinc & 4 \tabularnewline
Chlorine electrolysis (chemicals sector) & 3 \tabularnewline
Steel by EAF & 0.55 \tabularnewline
Cement & 0.11 \tabularnewline
\hline
\end{tabular}
\caption{Estimations of electricity consumption by produccion (MWh/t)}
\end{table}

\textsuperscript{6} [https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf](https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf)

\textsuperscript{7} The recognition of a special legal status in France is restricted to companies that are heavy consumers of electricity, and not of other energy resources, such as fossil fuels, etc. Hence, the precision of “electro-intensive industries” is a legal denomination for the kind of companies we refer to in this section, instead the wider and common term of “energy-intensive industries”. Throughout this document we will refer to energy-intensive industries, but if the French law specifies something exclusively about “electro-intensive industries”, this will be specified.

\textsuperscript{8} Source: Syndex, based on technical reports on electricity consumption in industry from different sources.

\textsuperscript{9} [https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI0000042655661/](https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI0000042655661/)
• The ratio between annual electricity consumption and the value added produced: the plant or the company should have an electricity consumption higher than 2.5 kWh per euro of added value during at least one of the two previous years (higher than 6 kWh for HEII).

• The degree of exposure to international competition: the plant or the company should carry out an industrial activity belonging to a sector where the intensity of trade with third countries is greater than 4% (in case of HEII: greater than 25% for HEII).

  o This intensity is defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total size of the market within the EU (annual turnover plus total imports from third countries).

• The electricity consumption: the company should have an annual electricity consumption of more than 50 GWh (no minimum consumption required for HEII).

As one of the main challenges faced by EIIs is the energy price, the French government has set up a wide range of measures aiming to “compensate” somehow the weight of energy in the production costs structure of the EIIs. Apart from other wide support programmes, the French government gives access to a few specific grants to companies categorised as electro-intensive and hyper electro-intensive:

• GHG allowance trading mechanism based on EU ETS\textsuperscript{10} established by EC directives and communications, last revised on 14 July 2021 for phase 4 (2021-2030)\textsuperscript{11}

  o Considering last EC communication on the “Guidelines on certain State aid measures in the context of the system for greenhouse gas emission allowance trading post-2021”\textsuperscript{12}, whose terms of application were adopted by law and updated in 2021 in Art.122-8 of the Energy Code\textsuperscript{13} and will be developed by regulatory means in 2022.

    ▪ This article established EII and other companies exposed to a significant risk of carbon leakage\textsuperscript{14} because of the costs of the EU ETS being passed on in electricity prices, shall be entitled to aid in accordance with the terms laid down by law.

\textsuperscript{10} The EU ETS set a maximum cap on the total amount of GHG that can be emitted by all industrial installations. The EU allowances system consists on the auction or allocation for free of allowances for emissions. Installations must monitor and report annually their CO2 emissions, ensuring they have enough allowances to cover their emissions. If emission exceeds what is permitted by its allowances, an installation must purchase allowances from others. On the other hand, if an installation has performed well at reducing its emissions, it can sell its leftover rights.

\textsuperscript{11} \url{https://ec.europa.eu/info/sites/default/files/revision-eu-ets_with-annex_en_0.pdf}

\textsuperscript{12} \url{https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020XC0925(01)&from=EN}

\textsuperscript{13} \url{https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000003381797/#!text=Version%20en%20vigueur%20d%20puis%2024%20de%20201%20janvier%202022&text=I.,les%20prix%20de%20l%E9lectricit%C3%A9%20A9.}

\textsuperscript{14} Carbon leakage refers to the eventuality that, as a result of the costs associated with climate policies, there is an increase in greenhouse gas emissions due to the transfer of companies’ production facilities to third countries that are not subject to comparable greenhouse gas emission regulations.
Because of sky-rocketing electricity prices, the French government has recently announced an additional compensation of €150 M for the EII, resulting from a reform of the calculation of CO2 emission offsets.

- Around 400 energy-intensive industrial sites (attached to the legal status of “electro-intensive industries” in France) will benefit from 2022.

- Participation in the “interruptibility” scheme set up by RTE (the transport system operator). RTE has the possibility of issuing a call for tenders for the contracting of interruptible capacities in less than 5 or 30 seconds at extraction sites with a subscribed power greater than 25 MW:
  - The price paid by RTE cannot exceed 120 €/kW.
  - The call for tenders is composed of two lots depending on the minimum interruptible power (25MW or 40MW).

- Reduction in the Tariff for the Use of Public Electricity Networks (TURPE):
  - 60% of maximum reduction rate for EII and 90% for HEII.

- A partial or total exemption from the CSPE\textsuperscript{15} (Contribution au Service Public de l’Electricité). There is a public debate about the fairness of such measures that benefit industry at the expense of higher contributions from households that do not benefit from the measures.
  - The regular rate is set at €22.5/MWh, but those EII for which the tax that would have been due would be higher than 0.5% of their added value, can benefit from partial exemptions (a reduced rate from €0.5 to €7.5/MWh).

Following the emergence of the EII legal framework in 2005, 27 companies of main energy intensive sectors joined in a consortium called Exeltium\textsuperscript{16}, whose purpose is to negotiate an optimal electricity supply contract on behalf of its shareholders and to finance it. The contractual structure negotiated by Exeltium mainly offers two advantages, i.e., the access to nuclear power plant competitiveness and a financial leverage and debt deconsolidation.

Figure 1. Industrial sites included in the Exeltium consortium, by sector

\textsuperscript{15}CSPE: a tax on electricity paid by companies, communities and individuals used to finance the support to renewable energies; additional electricity costs in areas not interconnected to the mainland grid; cogen-eration; the energy voucher mechanism intended for low-income households; and the injection of biomethane into gas networks.

\textsuperscript{16}https://www.exeltium.com/?lang=en/
Exeltium negotiated with EDF for 5 years to get the EC approval on its contractual scheme for which Exeltium’s shareholders paid €1.75 bn to EDF in 2010, a sort of "entry fee" to benefit from a volume of electricity at a reduced price for the following 24 years. The recently announced intention of French government to build 6 EPRs (third generation nuclear power plants based on pressurised water reactors) will require a €51.7 bn, excluding financing costs. Apart from the inevitable contribution of the State, several options are under study to finance its construction, such as a guaranteed price system or the participation of EDF’s major customers in a similar way to the mentioned contract signed by Exeltium and EDF.

There is other traditional employers’ association, Uniden17, which encompasses a larger number of energy-intensive companies from several sectors18 (with and without legal “electro-intensive status”) which are also addressed in this report.

1.2. MAIN CHARACTERISTICS OF THE EII SECTORS

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17 Since 1978 this association represents the interests related to the issue of energy supply at long term for a larger number of companies and more energy intensive sectors than Exeltium.

For the purpose of the present research, the iron and steel industry represents the metallurgy of alloy and non-alloy steels as well as ferro-alloys. The two main activities in the sector are:

- **Basic steelmaking**: transformation of raw iron ore or scrap metal into steel, through two routes of production:
  - Blast furnace (BOF), from iron ore using carbon-based reduction processes to produce liquid steel, where energy cost accounts for around 11% of total production costs.\(^{19}\) This production way represents around 64% of French steel production today.
  - Electric arc furnace (EAF), from scrap metal directly exposed to an electric arc to produce liquid steel, where electricity costs are more important than in BOF, accounting for around 14% of total production costs.\(^{13}\) This production way represents around 36% of French steel production.

- **Primary processing activities**, where energy costs account for 11%-20% depending on the route (BOF or EAF) and products\(^{20}\): The primary processing activities include, inter alia, the production of semi-finished products (blooms, billets and slabs), flat and long products issued from rolling mills, profiling of flat and long products, drawing and wire drawing (manufacture of bars and wire rod), the extrusion.

The employers insist on production overcapacity in Europe as opposed to weak demand. This is the argument commonly used by company management for the capacity closures that have been taking place over the past 20 years. However, the real reasons for these closures have less to do with overcapacity than with strong international competition, progressive replacement of domestic steel by cheaper (and less environmental) imported products (mainly from China), and the relocation of production to countries with lower labour and tax costs by players traditionally based in Europe. These processes have led to a decline in employment (-28% in 2019 compared to 2007) also driven by technological advances that have increased productivity in the sector.

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Both trends, production and employment, are shown on the graphs below (source: Eurofer and Eurostat).

**NON-FERROUS METALS**

The non-ferrous metal sector includes activities of extraction, production, processing and recycling of metals and industrial minerals, such as aluminium, copper, nickel, cobalt, lithium, manganese, etc.

Given the importance of the aluminium in France, this report focuses on recent evolution of the metal in terms on production and employment as seen below. Against this fact, global data are available regarding productivity and GHG emissions.\(^{21}\)

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\(^{21}\) As stated in the introduction to this report, one of the main limitations found when drafting this final version is the difficulty to find coherent and broken-down statistics by sector.
The electricity prices are a critical factor for the sustainability of the non-ferrous metals industry because their productions are among the most energy-intensive activities in the whole industry, multiplying by 10 (in the case of zinc) and up to 30 (in the case of aluminium) the electricity consumption required for the steel production in an electric furnace.

There is a very high demand outlook between now and 2050 for metals such as aluminium, copper, graphite, nickel, cobalt, lithium or manganese, due to the prospects of Li-ion battery production for electric vehicles, driven by mobility decarbonisation policies worldwide, as well as high demand for consumer electronics. Even though the production costs of Li-on batteries have fallen significantly over the last decade (from about $1,000/kWh in 2007 to around $150/kWh in 2020), the prices of the raw materials have actually been rising. Since 2015 the price of lithium has tripled, that of cobalt has doubled. Even though the total price of the batteries is supposed to keep on decreasing in the future, the prices of the raw materials are estimated to go up even further, which raises doubts as to what net impact these developments will have on non-ferrous industry and employment.

On the other hand, the exorbitant growth in demand calls into question the capacity to extract and supply minerals, raising the prospect of shortages. High lithium prices have failed to boost investment in new capacity due to lower long-term contract prices, while the difficulties in supplying cobalt are that it is a by-product of copper and therefore dependent on copper prices, and that almost 70% of cobalt is produced in the Democratic Republic of Congo, where supply disruptions already occurred due to political turmoil and where ethical and ecological concerns sparked a demand for measures to ensure the traceability of cobalt in accordance with international agreements.

Source: SBS Eurostat.

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22 Type of rechargeable battery composed of cells in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge and back when charging.
The chemical sector encompasses a multiplicity of highly diverse activities (see footnote 5) represented each by a different employers' organisation, although all of them are included in a supra-organisation, FrancheChimie.

The sector is the seventh in the world and the second largest in Europe behind Germany. It is in full expansion, despite 5% decrease of sales in 2020 as a result of Covid-19 impacts (sales are 12% higher than in 2010). Approximately 84% of the production is destined to export, positioned itself as the first largest export sector in France, ahead of the agri-food industry and the aeronautics industry.

The sector represents 3,300 companies, around 424,000 workers throughout all the chain of value (219,000 taking only into account the number of employees working for Franchemie's companies) and 18 “chemical platforms”, a particularity of the French market, which consists on territorial associations and clusters of manufacturers, subcontractors and suppliers coming together to pool services and infrastructures and reduce their investments and operating costs (the whole sector reached €3.2 bn in CAPEX and €1.9 bn in R&D expenditure in 2020).

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23 Turnover is included instead of production data because the chemicals sector encompasses many very different segments whose outputs cannot feasibly be included as a single production figure.
As shown above, the chemicals sector, which has undergone strong technological investment over the past decade, has increased its labour productivity to reach 125K€ per FTE worker in 2018. Among other factors, automation and digitalisation together with restructuring following mergers of some market players have led to a decline in employment by -16% in 2018 compared to 2010 (-21% in 2020 compared to 2010).

CEMENT

Among the sectors under study, the cement industry is the least energy intensive (around 110kW to produce a ton of cement).

The main players in French cement industry are: Ciments Calcia-Heidelberg Cement Group, Imerys Aluminates, Holcim (result of the merger between Holcim and Lafarge), Eqiom Groupe CRH and Vicat. There is a multiplicity of associations/professional organisation representing the interest of the cement industry and they are all gathered and represented at national level by “La Filière Béton”, the representative body for all actors in the various cement activities.

According to Infociments data, the sector exported 914.2 Mt of cement and 274.2 Mt of clinker in 2019 while it registered imports of 3,073.6 Mt of cement and 1,035 Mt of clinker in the same year. The development of the cement sector in France over the last decade has been marked by the sharp decline and weak demand in the construction market since 2008, which has not been able to recover pre-crisis levels (-29% decrease in production in 2020 compared to 2008), and by the merger process in 2015 of the main French player and one of the largest in the world, Lafarge, with its Swiss competitor Holcim. The merger, which was originally presented as “a merger of equals”, supposing the consolidation of a stronger macro-group, with a worldwide presence and capable of competing with the emerging Chinese players, has turned into a massive group in which decision-making has shifted to Holcim’s managers, who have had to sell numerous assets (in many countries and emerging markets) to deleverage the group and restructure its central services (which led to the closure of the Paris offices).

24 Four employers’ associations: the Federation of the Concrete Industry (FIB), the National Union of Ready-Mixed Concrete (SNBPE), the National Union of Quarry and Building Materials Industries (UNICEM); and the National Union of Aggregate Producers (UNPG). Three professional organisations with specific missions: French Union of the Cement Industry (SFIC), CIMbéton (the information centre on cement and its applications). Other entities as the Syndicat Français de l’Industrie Cimentière (SFIC), CIMbéton and the Technical Association of the Hydraulic Binders Industry (ATILH).

25 https://www.infociments.fr/
After the impacts of the 2008 crisis, the sector recovered employment in 2017 and 2018 (now stands at over 40,000 workers considering cement, lime and plaster activities throughout all the value chain).

### 1.3. GHG PERFORMANCE BY SECTOR

| Table 1. Evolution of GHG emissions in France and EU27 by sector |
|---------------------------------|-------|-------|----------|----------|
| STEEL                           | 11,950.337 | 9,203.846 | 5,159.347 | -56.8%      | -43.9%      |
| EU27                            | -50.5%  | 26.6%   | -50.5%   | 26.6%       |
| NON-FERROUS METALS              | 2,002.471 | 1,182.110 | 838.385  | -58.1%      | -29.1%      |
| EU27                            | -22.1%  | -20.6%  | -22.1%   | -20.6%      |
| CHEMICAL                        | 15,118.465 | 17,429.864 | 12,547.913 | -17.0%      | -28.0%      |
| EU27                            | -34.5%  | -20.5%  | -34.5%   | -20.5%      |
| CEMENT                          | 10,937.299 | 9,108.285 | 6,806.672 | -37.8%      | -37.8%      |
| EU27                            | -20.8%  | -21.3%  | -20.8%   | -21.3%      |

Source: Syndex, based on data from EEA.
GHG emission reduction in the 4 energy-intensive sectors analysed in France between 2005 and 2019 were higher than the EU27 average for steel, non-ferrous metals and cement sector, is not the case for the chemical sector, where the reduction of GHG emissions in France is well below the European average (Table 1). However, and against this apparently positive trend in EU and France, it must be taken into account the deindustrialisation process that has severely hit industrial sectors all around Europe since several years\textsuperscript{26}. Table 1 above and the graphs (13-16) below must therefore be taken as a reference but not as the sole and exclusive result of decarbonisation policies, as this decline is influenced by the closure and relocation of activities, both in France and in most of Europe.

\textsuperscript{26}For the steel and iron sector, the main player, ArcelorMittal has reduced in a significant way its geographical scope; for the non-ferrous sector the leading players in the aluminium activity have undergone a delocalisation strategy based on carbon leakage and recently one of the main players on the silicium and manganese activities (Ferroglobe) has announced its intention of closing several sites in France. Similarly the merger between Holcim and Lafarge has finally led to the closure and/or sell of different facilities.
#1
ANALYSIS OF THE DECARBONISATION PATHWAYS
2.1. MAIN DECARBONISATION PATHWAYS

A portfolio of technologies and approaches will be needed to address the decarbonisation challenge. For the moment, the EII have identified several technology pathways that could enable deep emissions reductions and companies are already working on concrete projects to implement them.

**Table 2. Overview of low-CO2 technology potential for energy-intensive sector**

<table>
<thead>
<tr>
<th></th>
<th>Electrification (heat and mechanical)</th>
<th>Electrification (processes: electrolysis/ Electrochemistry excl. H₂)</th>
<th>Hydrogen (heat and/or process)</th>
<th>CCU</th>
<th>Biomass (heat and feedstocks/biofuels)</th>
<th>CCSS</th>
<th>Other (including process integration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>xxx</td>
<td>xx</td>
<td>xxx</td>
<td>x</td>
<td>xxx</td>
<td>xxx</td>
<td>Avoidance of intermediate process steps and recycling of process gases: xxx Recycling high quality steel: xxx</td>
</tr>
<tr>
<td>Chemicals fertilizers</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx(*)</td>
<td>Use of waste streams (chemical recycling): xxx</td>
</tr>
<tr>
<td>Cement Lime</td>
<td>xx (cement)</td>
<td>o (limestone)</td>
<td>x (lime)</td>
<td>xxx</td>
<td>xxx (cement)</td>
<td>x (lime)</td>
<td>Alternative binders (cement): xxx Efficient use of cement in concrete by improving concrete mix design: xxx Use of waste streams (cement): xxx</td>
</tr>
<tr>
<td>Refining</td>
<td>xx</td>
<td>o</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>Efficiency: xxx</td>
</tr>
<tr>
<td>Ceramics</td>
<td>xxx</td>
<td>o</td>
<td>xx</td>
<td>x</td>
<td>x</td>
<td>o</td>
<td>Efficiency: xxx</td>
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<td>Paper</td>
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<td>xxx</td>
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<td>xxx</td>
<td>Efficiency: xxx</td>
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<tr>
<td>Glass</td>
<td>xxx</td>
<td>o</td>
<td>x</td>
<td>o</td>
<td>xxx</td>
<td>o</td>
<td>Higher glass recycling: xx</td>
</tr>
<tr>
<td>Non-ferrous metals/ alloys</td>
<td>xxx</td>
<td>xxx</td>
<td>x</td>
<td>x</td>
<td>xxx</td>
<td>x</td>
<td>Efficiency: xxx Recycling high quality non-ferrous: xxx Ingot anodes: xxx</td>
</tr>
</tbody>
</table>

α: Limited or no significant application foreseen  
κ: Possible application but not main route or wide scale application  
κκκ: Sector already applies technology on large scale (can be expanded in some cases)  
κκ: high potential  
κκκκκ: medium potential  
(*) in particular for ammonia and ethylene oxide

Source: “Masterplan for a competitive transformation of EU Energy Intensive Industries”
While various technologies are being studied (as shown by Table 2) there is a widespread consensus on the main ones:

- Material efficiency.
- Material recirculation.
- Hydrogen technology.
- Carbon Capture, Utilisation and Storage (CCUS) technologies.

**Energy and resource efficiency measures**, along with material substitution, reduce the level of energy and materials used in production and keep industrial products and materials in use for longer. This will be crucial in getting industry to net zero. It is estimated that these measures could contribute in a significant way to reducing annual emissions and to decrease the overall cost of decarbonisation by lowering the amount of energy that needs to be converted to cleaner sources and by reducing operational costs.

Energy and resource efficiency improvements will play a particularly significant role in reducing industrial emissions in the 2020s, leading the way in terms of widespread emissions reductions whilst the infrastructure for deep decarbonisation options is built up throughout the decade. This is especially important for the iron and steel sector as shown below.

**Figure 17. Reduction of direct CO2 emissions in the steel industry (IEA SDS vs. STEPS scenario by type of emission reduction strategy)**

By maximising energy and resource efficiency in the 2020s, the total cost of decarbonisation will be reduced because the level of emissions to be abated through expensive deep decarbonisation measures will be lower.

**Material recirculation** may allow large emissions reductions. Steel, cement, chemicals, and aluminium are produced via carbon-intensive processes. In addition to direct greenhouse gas
emissions from these materials, they are also a large source of waste creation. In the aluminium sector, recycling and resource efficiency is considered as one of the three pathways to decarbonisation.

**Hydrogen technologies** are one of the main decarbonisation pathways identified by the European Union which currently produces 10 Mt/year of hydrogen, mainly grey (issued from gas).

The European targets are based on the installation of 6 GW of electrolysers to produce 1 Mt/year of green hydrogen by 2024 and an additional 40 GW by 2030 to produce 10 Mt of "renewable" hydrogen. As a result, the share of hydrogen in the European energy mix is expected to rise from the current 2% to 14% by 2050.

However, the main issue is the production of decarbonated hydrogen which involves electrolysis, provided that decarbonated electricity is used, mainly from renewable energy (electrolysers are placed close to the production sources and convert the electricity into storable hydrogen). France could have an advantage in this respect because of the importance of nuclear energy in its electricity grid. Nuclear power plants could supply the required heat and electricity to produce hydrogen without generating any carbon emissions. But this combination of technologies is only under study for the time being.

The hydrogen pathway seems to be favoured by the iron and steel industry. Hydrogen direct reduction of iron ore (HDRI)-EAF-based steel production is the most viable alternative to BF-BOF based steel production, because the production of hydrogen with intermittent renewable energy generators has the additional benefit of giving the electricity grid flexibility. Large-scale production, storage, and transport of hydrogen to cater to the demands of the steel industry could also reduce the price of hydrogen for other industries such as chemical production, transportation, buildings, district heating etc.

**Carbon capture, utilisation, and storage (CCUS) technologies** can play a critical role in reducing industry sector CO2 emissions alongside energy efficiency electrification (including electrolytic hydrogen) and the increased direct use of renewable energy.

In the IEA Clean Technology Scenario (CTS), which maps out a pathway consistent with the Paris Agreement, CCUS contributes almost one-fifth of the emissions reductions needed across the industry sector.

In the CTS, more than 28 gigatons of carbon dioxide (GtCO2) is captured from industrial processes in the period to 2060, most of it from the cement, iron and steel and chemical subsectors.

*Figure 18. CCUS emissions reductions by subsector in the CTS, 2017-60*
However, concerns over the safe transport and storage of captured carbon make CCUS options less attractive. The effective management of large volumes of CO2 from industrial production will in fact require the planning and development of CO2 transport and storage infrastructure in the near term. These investments can have lead times of several years, particularly for pipelines and for greenfield CO2 storage sites and for the time being they are a factor limiting CCUS uptake.

### 2.2. MAIN DECARBONISATION PATHWAYS BY INDUSTRY AND TECHNOLOGY

**STEEL AND IRON INDUSTRY**

The iron and steel sector is an energy-intensive industry. Coal accounts for about 75% of energy inputs and the majority is consumed in blast furnaces. Electricity is the second largest energy input, mainly used by electric furnaces, followed by gas, which is mainly used for generating heat and as a reducing gas in DRI furnaces.

Although energy intensity has declined over the past two decades, this decline has been largely offset by increased global steel production. Energy intensity depends mainly on the proportion of scrap and iron ore. Primary production of steel (BF-BOF) is about eight times more intensive than electric arc production (EAF).

<table>
<thead>
<tr>
<th><strong>Scrap metal recycling</strong></th>
<th><strong>Problems:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Some qualities can only be provided by the cast iron route</td>
</tr>
<tr>
<td></td>
<td>• Scrap collection and sorting technologies are inefficient</td>
</tr>
<tr>
<td></td>
<td>○ Solution: R&amp;D and investment through the Reverse Metallurgy programme</td>
</tr>
<tr>
<td></td>
<td>• Expensive or insufficient electricity, especially renewable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Carbon capture and utilisation technologies (CCU or CCS)</strong></th>
<th><strong>Problems:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Feasibility is unproven</td>
</tr>
<tr>
<td></td>
<td>• High costs: it is estimated that CO2 capture on a new thermal (coal) power plant costs about ~$50-60 per ton of CO2. The amount is higher for old steel plants</td>
</tr>
</tbody>
</table>

---

27 Steel consumption accounted for 15% of global primary demand in 2019.

28 About 25% for converting iron, direct reduced iron and scrap into steel, then for semi-finish and finishing processes.

29 This ratio can be lower in the European steelmaking industry.
The CCS installation on the Norcem cement plant in Norway took nine years and received final approval in April 2020. Costs and performance are not known.

### Producing steel using renewable or nuclear energy

Options expensive in investment and not yet sufficiently developed:
- Electrolysis of iron ore
- Direct reduction of iron by hydrogen
- Plasma smelting of iron ore

The technology readiness level (TRL) is a way of assessing how mature a technology is, from the initial idea to full-scale market release. This tool provides a common framework that can be applied to any technology, allowing it to be compared. Table 4 below assesses the importance of the emission reduction impact and the maturity of the technologies currently under development on a scale of 0 to 10, with 10 being the highest value in terms of development and applicability.

**Table 4. Status of the main near-zero emission technologies in the iron and steel sector**

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>TRL</th>
<th>YEAR AVAILABLE</th>
<th>IMPORTANCE FOR NET-ZERO EMISSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CCUS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast furnace: off-gas hydrogen enrichment and/or CO₂ removal for use or storage.</td>
<td>5</td>
<td>2030</td>
<td>Very high</td>
</tr>
<tr>
<td>Blast furnace: converting off-gases to fuels.</td>
<td>8</td>
<td>Today</td>
<td>Medium</td>
</tr>
<tr>
<td>Blast furnace: converting off-gases to chemicals.</td>
<td>7</td>
<td>2025</td>
<td>Medium</td>
</tr>
<tr>
<td>DRI: natural gas-based with CO₂ capture.</td>
<td>9</td>
<td>Today</td>
<td>Very high</td>
</tr>
<tr>
<td>Smelting reduction: with CCUS.</td>
<td>7</td>
<td>2028</td>
<td>Very high</td>
</tr>
<tr>
<td><strong>HYDROGEN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast furnace: electrolytic H₂ blending.</td>
<td>7</td>
<td>2025</td>
<td>Medium</td>
</tr>
<tr>
<td>DRI: natural gas-based with high levels of electrolytic H₂ blending.</td>
<td>7</td>
<td>2030</td>
<td>High</td>
</tr>
<tr>
<td>DRI: based solely on electrolytic H₂.</td>
<td>5</td>
<td>2030</td>
<td>Very high</td>
</tr>
<tr>
<td>Smelting reduction: H₂ plasma reduction.</td>
<td>4</td>
<td>-</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Ancillary processes: H2 for high-temperature heat. | 5 | 2025 | High

DIRECT ELECTRIFICATION

Electrolysis: low temperature. | 4 | - | Medium

Electrolysis: high temperature molten oxide. | 4 | - | Medium

BIOENERGY

Blast furnace: torrefied biomass. | 7 | 2025 | Medium

Blast furnace: charcoal. | 10 | Today | Medium

Source: IEA.

Bringing technologies to market in the early stages of maturity depends on increased R&D and demonstration. Support through policy action is, therefore, very important. Another key aspect is that the necessary inputs (renewable electricity and low-carbon hydrogen) and infrastructure (CO₂ pipelines and storage facilities, electricity grids, hydrogen networks) must be available.

CEMENT INDUSTRY

Figure 19. Several scenarios for the decarbonisation sector

The cement sector represents one of the most challenging sectors in the zero-carbon transition as:

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30 The European Commission’s Science and Knowledge Service “Deep decarbonisation of industry: the cement sector”
Traditional cement making using clinker emits high levels of process emissions and requires substantial amount of heat, mainly provided by carbon-intensive fossil fuels such as coal.

As yet, no alternative production technologies exist that combine technological maturity and economic cost-competitiveness, while ensuring similar output.

However, no clear and unique pathway prevails, with CCUS sidelined due to the process emissions inherent in cement making.

**CHEMICALS INDUSTRY**

As with the cement sector, the chemicals industry is often identified as “hard to abate” as it is built on hydrocarbons (both as a feedstock and as a source of energy). As for the cement industry, the hydrogen issue and CCUS are thus crucial for the chemical sector.

Other decarbonisation pathways may include:

- Improving resource and energy efficiency for chemical and material production processes:
  - This could be achieved by developing new digital tools (such as predictive analytics, advanced visualisation, and AI-driven energy management applications).

- Using sustainable waste or bio-based raw materials (such as vegetable or animal fats, sugar, lignin, hemicellulose, cotton, maize, or algae) to produce bio-based chemicals (such as alcohols, organic acids, and polyesters):
  - Their use is limited, due to competition with the food sector, biofuels, and bioenergy; and due to physical constraints, such as soil erosion, water scarcity or reduced biodiversity.
  - In addition, they present a moral problem in determining whether to use these products for production or for direct food.

- Avoid the production of virgin materials (such as polymers, rubbers, batteries, packaging materials, solvents, or lubricants):
  - This could be achieved through reuse, mechanical or chemical recycling, or alternative use in other applications.
  - But the disadvantage of circularity is that these materials account for only 20% of the chemical industry, so their potential impact is limited.

**ALUMINIUM INDUSTRY**

According to the IAI\(^\text{31}\) the global aluminium industry would need to reduce its total emissions to 250 Mt CO2e, from a 1.1 Gt CO2e 2018 baseline and a projected 2050 Business As Usual scenario of 1.6 Gt CO2e. Three main decarbonisation pathways have been identified by the IAI:

\(^\text{31}\) [Aluminium Sector Greenhouse Gas Pathways to 2050](https://www.aluminium.org/)

Electricity decarbonisation

Direct emissions reduction

Recycling & resource efficiency

Electricity decarbonisation

Figure 20. Electricity decarbonisation on aluminium production

Source: IAI

According to the IAI32 more than sixty per cent of the aluminium sector’s 1.1 bn tonnes of CO2e emissions (2018) are from the production of electricity consumed during the smelting process. As seen in the above graphs, decarbonised power generation and the deployment of CCUS offer the most significant opportunity for emissions reduction for the aluminium producers.

Direct emissions reduction

According to the IAI33 direct emissions from the combustion of fuels to produce heat and steam make up 15% of the sector’s 2018 emissions (coming from alumina refining, anode production, casting, remelting and recycling processes).

Figure 22. Direct emissions potential

Source: IAI

As seen above, for these processes, electrification with low carbon sources is identified as a potential pathway to decarbonisation combined with green hydrogen and CCUS when electrification is not possible.

32 « Aluminium Sector Greenhouse Gas Pathways to 2050»
33 « Aluminium Sector Greenhouse Gas Pathways to 2050»
Breakthrough technologies in emission reduction are nowadays being developed, the inert anodes\(^\text{34}\) being the most important one.

**Recycling & resource efficiency**

One of the main characteristics of aluminium is its infinite recyclability. Whereas today, according to the IAI, the recycling of post-consumer scrap avoids the need for almost 20 Mt of primary aluminium (i.e., 300 Mt CO2e every year) there are still around 7 Mt of aluminium lost during the recycling process. The main big challenges relate to the improvement of scrap collection rates and increased circularity.

2.3. **MAIN DECARBONISATION PATHWAYS AS IDENTIFIED IN FRANCE**

Regarding the state of development and specific weight of each of the 4 decarbonisation pathways applied to France, it is already possible to make a first assessment of the specific weight of each technology pathway.

The French industry is quite advanced in terms of **energy and material efficiency** and in **materials recirculation**. All the sectors analysed have numerous projects for energy efficiency, reuse of gases or waste from their production processes both in the case of the iron and steel, chemical, cement and aluminium sectors. There are also measures in place in all EII sectors for the substitution of carbon-emitting products with less or zero carbon-emitting materials. Many of the energy and material efficiency and material recirculation measures are already being applied and those under development will be implemented in the coming years before 2030.

The state of development of **carbon capture, utilisation and storage technologies** is very different. There are few projects which, although they could benefit companies in all the sectors analysed, are mostly at the study and analysis stage. The most mature project seems to be the one under development by the consortium of chemical companies Air Liquide, Borealis, ExxonMobil, Total and Yara International to create a major carbon-capture-and-storage facility in Normandy, France. The companies plan to capture up to 3 million metric tons per year of carbon dioxide that would be stored under the North Sea. The consortium is now seeking funds

\(^{34}\) Inert anodes emit oxygen instead of CO₂. Russian producer Rusal and the Elysis JV (Rio Tinto + Alcoa) are currently working on the issue.
from EU and French government and aims to be operational by 2030. This seems too optimistic considering that the rest of the carbon capture projects in France are not expected to be in place until the 2040s. For its part, the cement sector’s roadmap foresees a very important role of carbon capture for its industries, even talking about an emissions reduction potential of up to 5Mt CO2 by 2050, constituting the main lever of transition towards decarbonisation in cement industry. However, this forecast seems to be too optimistic given the current state of the CCS and CCU projects.

The least developed pathway so far is undoubtedly the use of hydrogen in production processes. There are only a couple of private projects in the steel and chemical sector. However, this delay seems to have been left behind by the drastic change in strategy brought about by the “France 2030” plan, whereby the French president announced the commissioning of two gigafactories of electrolysers for the massive production of hydrogen, which would be operational by 2030.

2.4. EMPLOYMENT IMPACTS OF DECARBONISATION PATHWAYS IN FRANCE

Given the still limited maturity of the companies’ decarbonisation strategies and the early stage of implementation of the national and sectoral policies on the issue of decarbonisation and the priority given to the technical issues by now, the issue of the social impact of the whole process is somehow neglected and no accurate assessment has been done till now on an extensive way.

However, some researches have already been done and one of the most recent ones (Deloitte study), which aims to assess the economic and climate impact of the production dynamics of the energy-intensive industries within UNIDEN, dynamics of production, consumption and international trade over the period 1995-2015 in France, confirms there was a progressive deindustrialisation in the EII sectors studied. While there was a decline in industrial production, the final consumption and imports were growing for most of the sectors. The decline in France’s export competitiveness is another common characteristic to all EII sectors.

The production deficit attributable to this deterioration in international trade is estimated at more than 3 billion euros at the end of the period 1995-2015, corresponding to a loss of €778

<table>
<thead>
<tr>
<th>Industry</th>
<th>Production savings (€ m)</th>
<th>Value-added gains (€ m)</th>
<th>Employment growth (FTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>574</td>
<td>141</td>
<td>1509</td>
</tr>
<tr>
<td>Aluminium</td>
<td>892</td>
<td>226</td>
<td>600</td>
</tr>
<tr>
<td>Cement</td>
<td>185</td>
<td>45</td>
<td>465</td>
</tr>
<tr>
<td>Paper</td>
<td>807</td>
<td>198</td>
<td>2050</td>
</tr>
<tr>
<td>PVC</td>
<td>467</td>
<td>150</td>
<td>647</td>
</tr>
<tr>
<td>Sugar</td>
<td>395</td>
<td>273</td>
<td>1444</td>
</tr>
<tr>
<td>Glas</td>
<td>465</td>
<td>114</td>
<td>1168</td>
</tr>
<tr>
<td>Total</td>
<td>3785</td>
<td>1147</td>
<td>7883</td>
</tr>
</tbody>
</table>

Source: 2021, Le redéploiement industriel, Deloitte

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35 2021, Deloitte. Industrial redeployment (Le redéploiement industriel): a social and economic challenge and a tool for to control our carbon footprint: Study of the impact of deindustrialisation on France’s carbon footprint of France, Deloitte
million in value added, and more than 13,000 jobs. Besides this economic and social consequences of the deindustrialisation, there is also an environmental cost. Deloitte assess an increase in the carbon footprint of almost 2,263 ktCO2e, as a climate impact of this deindustrialisation, attributable both to the transfer of large volumes of production to other European countries and to other non-European countries, which are the latter more limited in volume, but very penalizing in terms of environmental impact.

Most findings on employment destruction do not distinguish between impacts linked to deindustrialisation and those linked to the implementation of decarbonisation policies and technologies, which are undoubtedly taking place. On the other hand, most studies emphasise the positive repercussions that the application of these technologies would have on the whole of the energy-intensive industry (see table 5), which could be a lever for boosting industrial activity by favouring the creation of new jobs (an employment growth of 7,883 FTE for EII sectors in France is foreseen by 2035 by Deloitte report) and more efficient, more competitive and above all more environmentally friendly production that would encourage private investment in a social climate and public policies that urge companies to produce in a more sustainable manner.

In this respect, the Deloitte study simulates a reindustrialisation scenario, based on a partial or total rebalancing of the trade balance of the products affected by deindustrialisation. A reindustrialisation scenario would not only have a positive impact in terms of production, added value and jobs, but also in terms of avoided CO2 emissions (see Table 6).

The greater environmental efficiency of French industries (favourable energy mix, low-carbon electricity mix), which should increase further because of France’s commitments in the framework of its energy-climate strategy, would make it possible to improve carbon footprint through backshoring. This reindustrialisation scenario would also lead to gains by 2035 of more than €3.7 bn in additional production, leading to 7,883 jobs created or saved. In terms of carbon footprint, 5,138 ktCO2e would be avoided, which represents an improvement of almost 99% of the carbon footprint of the products in question.

Taking into account previous analyses, decarbonisation could be a lever to boost reindustrialisation in France, and by extension in Europe, leading to potential growth in industrial employment.
ANALYSIS OF THE NATIONAL DECARBONISATION STRATEGY
3.1. OVERALL NATIONAL STRATEGY

There is a strong demand of companies with regards to the public support to the decarbonisation strategy; in fact, companies argue that the achievement of the decarbonisation targets will require huge capital expenditure that they could not afford without public financial support.

To give an answer to this increasing demand the president of the Republic announced mid-October 2021, the “France 2030” Plan\textsuperscript{36}, which consists in a massive investment plan to boost technological advances and help the transition of key sectors of French industry as energy, automotive or aeronautics. The investment plan is endowed with €30 bn over five years to ten strategic sectors, of which €3 to €4 bn will be allocated to companies in 2022, to achieve 10 main objectives by 2030.

The break-down of the plan includes:

- an investment of more than €8 bn on:
  - Nuclear energy: bringing about the emergence of small, innovative nuclear reactors with better waste management (€1 bn).
  - Green hydrogen: by 2030, France should have at least two gigafactories of electrolysers and will massively produce hydrogen and all the technologies needed for its use.
  - GHG emissions reductions: a decrease of 35% compared to 2015.

- An investment of €4 bn on the issue of future transports (produce nearly 2 million electric and hybrid vehicles and produce the first low-carbon aircraft)

Decarbonisation of industry is a key part of this new plan as a follow-up of the first climate plan issued in 2017. This climate plan was integrated into the National Low Carbon Strategy\textsuperscript{37} (SNBC) revised in March 2020, which in turn forms part of the National Integrated Energy-Climate Plan\textsuperscript{38}. This strategy, originally created by the law on energy transition and green growth (LTECV)\textsuperscript{39} voted in 2014, aims to boost the effort to mitigate emissions into five-year periods. The current version, in addition to including an objective of carbon neutrality in 2050, also defines a carbon budget for the period 2029-2033. This strategy of estimating a carbon budget thus aims to match the evolution of the production and consumption systems with the maximum amount of carbon dioxide that is allowed to be emitted.

The strategy of carbon neutrality by 2050 implies first a complete decarbonisation of the French energy system. The targets set in the national policy include:

\textsuperscript{36} https://www.elysee.fr/emmanuel-macron/france2030
\textsuperscript{37} https://www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf
\textsuperscript{38} https://www.ecologie.gouv.fr/sites/default/files/2019%2002%2014%20projet%20de%20PNIEC%20France_Versi
on%20consolidee.pdf
\textsuperscript{39} https://www.legifrance.gouv.fr/loda/id/JORFTEXT000031044385/
• A complete withdrawal from fossil fuels.
• Based on a total consumption between 1,100 and 1,400 TWh in 2050 - compared to more than 3,000 TWh in 2017 - the associated energy mix would then break down into renewable and recovered heat or biomass systems for around 400 TWh, decarbonised electricity (between 600 and 650 TWh) and renewable gas production (between 195 and 295 TWh).
• Emissions of the industrial sectors should be divided by a factor of more than five by 2050 thanks to:
  o Energy efficiency gains,
  o An increase in the electrification of energy demand,
  o The development of recycling and circular economy.
• The use of low-carbon materials and wood as a means of reducing demand for high-emitting products while storing carbon.

According to this general strategy, GHG emissions would be around 80 MtCO2eq in 2050, including 47 MtCO2eq of CH4 and N2O and 16 MtCO2eq from the industry sector. Forests and wood would account for most of the carbon sinks, with over 52 MtCO2eq. Carbon capture and storage technologies that are still under development are beginning to be commercialised worldwide and are estimated to capture 16 MtCO2eq.

### 3.2. INDUSTRIAL STRATEGY AT NATIONAL LEVEL\

The industry sector emitted 81 MtCO2eq in 2017, i.e. 17.4% of national emissions. These emissions fell sharply between 1990 and 2017 (-44% over the period).

84% of these emissions are subject to the European Union’s GHG emissions trading scheme (EU ETS), to which emissions from electricity production are also subject. CO2, mainly from the minerals, metallurgy and chemical industries, is the main gas emitted by industry: it accounted for 89.7% of the sector’s GHG emissions in 2017, followed by HFCs, mainly from refrigeration processes (6.4% of emissions), N2O (2.6% of emissions) and other GHG (1.3% of emissions) such as PFCs, CH4 and SF6. These emissions are partly due to the combustion of energy required for industrial production (64% in 2017) and partly to industrial processes (36% in 2017).

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40 The decarbonisation strategy at global industrial level was set in 2019; further developments have been set in 2020 with regards to global and specific targets.
In 2019, France’s policy for reducing GHG emissions in the industrial sector was based mainly on:

- Capping the emissions of the most emitting industrial installations via the European Emissions Trading Scheme (ETS);
- Improving energy efficiency via energy saving certificates, and requiring large companies to carry out energy audits every 4 years since 2015;
- Increasing the share of renewable energy used in industry with the heat fund managed by ADEME (which helps finance the use of renewable energy, particularly biomass for heat production to replace fossil fuels);
- Supporting innovation actions within companies for innovation through the Investment for the Future programme (PIA, Pogramme des Investissements d’Avenir).

The 2019 reviewed national strategy for industry sector aims to reduce the sector’s emissions by 35% by 2030 compared to 2015 and by 81% by 2050. Although the total decarbonisation of the sector by 2050 is not envisaged since emissions are currently considered to be irreducible by that date, the 2050 target is nevertheless very ambitious. The residual emissions in 2050 will have to be compensated by the carbon sink of the land sector and/or by carbon capture and storage facilities. According to the current state of knowledge, the irreducible emissions in 2050 will come from the production of mineral products, primary metallurgy, certain chemical processes and fluorinated gases. While the energy consumed will be completely decarbonised by that time. The ways of reducing emissions from these processes have yet to be determined.

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41 Source: CITEPA inventory May 2019 in SECTEN format and at Kyoto Climate Plan perimeter, non-climate corrected data.
42 [https://www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf](https://www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf)
The main orientations of the industrial strategy to decarbonization are:

- Supporting companies in their transition to low-carbon production systems and the development of new value chains.
- Starting today the development and adoption of breakthrough technologies to reduce and eliminate residual emissions if possible.
- Providing a framework to encourage the control of energy and material demand, with a focus on low-carbon energy and the circular economy.

As shown in the following chapter the public authorities intend to play a significant role to accompany national industry through its journey to zero-carbon.

### 3.3. GOVERNMENT AID PROGRAMMES FOR INDUSTRY

France has been investing in climate actions around €40Bn (public and private investments) on average between 2011 and 2018. According to the revised SNBC, it plans to increase on average €15 to €18 bn per year for the period 2019-2023.

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43 Source: CITEPA inventory 2018 in SECTEN format and Kyoto Climate Plan perimeter; AME and AMS 2018 scenarios
Apart from the recent commitment of the French government to invest €30bn, a previous programme was launched to guide all players in the economy to achieve the decarbonization targets. This guided path\(^{44}\) has been developed in collaboration with ADEME engineers, industrialists and consultancies.

The French government has deployed a wide range of mechanisms to boost the decarbonisation of industry\(^{45}\) as part of its “France Relance” strategy and “Agir pour la decarbonation” strategy since 2020. Some of the following aids are also complementary:

- The Industry Decarbonisation Fund (“Fonds Décarbonation de l’Industrie”), operated by ADEME, to support industrial companies in the use of heat sources that emit less CO2, for investments of over 3M€.

- Investment support for complex projects to decarbonise industrial processes.

- The support to produce low-carbon heat using biomass (Call for BCIAT projects) in the framework of the Heat Fund (“Fonds Chaleur”), operated by ADEME.

- An additional aid to produce low-carbon heat using Solid Recovered Fuels (SRF) in the framework of the Circular Economy Fund and the Industry Decarbonisation Fund, operated by ADEME.

- The support for energy efficiency projects (from a predefined list) in the industry, operated by ASP (Payment Service Agency), for investments of less than 3M€. The aids cover industrial investments in the fields of energy efficiency, electrification and process adaptation that reduce CO2 emissions.


In Jun 2021, as part of the Recovery Plan 1,2 Bn€ until 2022 were allocated to ADEME (Agence de la Transition Ecologique) and to the ASP (Agence des Services de Paiements) to extend the system of aid already mentioned.

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\(^{44}\) https://agirpourlatransition.ademe.fr/entreprises/demarche-decarbonation-industrie/agir

\(^{45}\) https://agirpourlatransition.ademe.fr/entreprises/france-relance-decarbonation-industrie
3.4. DECARBONISATION SECTORAL STRATEGIES

The following decarbonisation targets and pathways are drawn from a series of national documents produced by the public administration with the participation of the main players in each sector and published between May and April 2021. Following the latest impulse of the French government through the new “France 2030” plan, these roadmaps are likely to change in the coming months:

- **Roadmap for the mining and metallurgy sector** (May 2021): this document contains the inventory of emissions from the ore and metallurgy industry and details the levers to reduce emissions broken down for 3 specific sub-sectors: integrated steel, aluminium and the metallurgy sector. It also details the public support available.

- **Roadmap for the chemical sector** (April 2021): this document contains the inventory of emissions from the chemicals sector, details the drivers to reduce emissions and describes projects already underway to meet the 2030 emissions in the chemical sector.

- **Roadmap for the cement sector** (April 2021): this document contains the inventory of emissions from the cement sector, details the drivers to reduce emissions, actions planned by the sector and the public aids to achieve the decarbonizing objectives.

**ROADMAP FOR THE MINING AND METALLURGY SECTOR**

According to EU ETS data, GHG emissions of the mining and metallurgy sector in France were 26 Mt CO2e in 2015: 21.7 Mt corresponds to integrated steelmaking (including emissions of DK6 thermal power plant located in Dunkirk at AM plant); 1.2 Mt to aluminium production and around 3.4 Mt CO2e to EAF production, downstream facilities and other metals.

The national low-carbon strategy sets a reduction target for the mining and metallurgy sector of 31% of GHG emissions between 2015 and 2030. **The identified direct emissions reduction trajectories are mainly focused on specific actions concerning the companies’ accounting for the biggest amounts of emissions**; this approach explains the support granted by the public authorities to private companies:

- Integrated steel sector: 31% of GHG emission reduction through reductions at Dunkirk and Fos-sur-Mer plants.

- Aluminium: between 5% and 9% of reduction by 2030 compared to 2015.

- Other metals: Eramet’s reduction targets are in tonnes of CO2 per tonne produced, i.e. carbon intensity of production, and should reach -7.3% by 2023 compared to 2018.

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47https://www.ecologie.gouv.fr/sites/default/files/2021.05.07_Annexe-au-cp_feuille_de_route_decarbonation_chimie.pdf
In the longer term, work is underway to build more ambitious decarbonisation trajectories to the 2050 horizon based on literature analysis and dialogue between industry and experts that will be reflected in sectoral Transition Plans. This work will also make it possible to assess the necessary investments, new decarbonisation drivers at sectoral level, impacts on employment and on their territorial implementation, and the public and private actions to be implemented.

<table>
<thead>
<tr>
<th>Table 7. Levers to reduce emissions in mining and metallurgy sector</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel</strong></td>
</tr>
<tr>
<td>Improving energy efficiency in steel production</td>
</tr>
<tr>
<td>Increasing recycling rate of circular steel</td>
</tr>
<tr>
<td>Smart Carbon: innovation and technological developments in steelmaking</td>
</tr>
<tr>
<td>Blast furnace steel industry</td>
</tr>
<tr>
<td><strong>aluminium</strong></td>
</tr>
<tr>
<td>Improving the control of the electrolysis process in the manufacture of primary aluminium</td>
</tr>
<tr>
<td>Improving energy efficiency in transformation and recycling of aluminium</td>
</tr>
<tr>
<td>Aluminium industry</td>
</tr>
<tr>
<td>Carbon footprint reduction in 2030 compared to 2015 (KtCO2e)</td>
</tr>
<tr>
<td>Increase in recycled aluminium production capacity in France, replacing primary aluminium imports</td>
</tr>
</tbody>
</table>

Source: Roadmap for the mining and metallurgy sector

REDUCTION DRIVERS FOR THE INTEGRATED STEEL SECTOR

The 31% target reduction for integrated steel sector is equivalent to 7,4Mt CO2e of total emissions including thermal power plants (5,8Mt CO2e of direct emissions without adjacent thermal power plants).

To achieve the objectives, the main measures are:

- The improvement of energy efficiency;
- the increase of the recycling rate;
- 2 innovative ways developed in French plants (Smart Carbon/ Green Blast Furnaces and DRI/ Hydrogen).

It must be noted that the decarbonisation roadmap for metallurgy in France is largely dependent on the decarbonisation strategy of ArcelorMittal⁴⁹ and thus the success of the national decarbonisation policy relies (too much?) on the success of ArcelorMittal’s decarbonisation policy. The time being there are different projects and initiatives of ArcelorMittal that are considered as being good practices:

- In Dunkirk on the issue of energy efficiency:
  - Optimisation of the blower systems producing the cold wind of the blast furnaces

The recirculation of hot gases at the end of the agglomeration chain (WGR waste gas recirculation project), combined with a project to improve the dedusting of the agglomerations;

- In Dunkirk and Fos-sur-Mer on the issue of circularity by 2024:
  - Increase in the recycling rate of circular steel at both facilities by maximising the loading of scrap in order to reduce the proportion of cast iron at the converter with the existing facilities; improving the logistics of scrap supply will also be necessary. The targeted CO2 reduction is expected to reach about 12% by 2030.
  - Through the Smart Carbon route, the following technological projects and developments would lead to a 19% reduction of CO2:
    - Reinjection of siderurgical gases and potentially the use of hydrogen as a substitute for fossil coal.
    - The use of gas from blast furnaces to generate ethanol or other precursor compounds for the polymer industry, which can be used by the petrochemical industry.
    - Generation of reducing agents and their use as a substitute for fossil fuels. Pulverized Coal Injection (PCI), a fossil fuel injected into blast furnaces, is replaced by charcoal from the torrefaction or pyrolysis of recovered wood, by plastic pellets/CSR or by gas from a process of gasification of various wastes (including plastics). For this process, which is totally new, many unknowns remain as to the real industrial performance and make us cautious about the accuracy of the gain estimates:
      - The plastic pellet production process will require many adjustments, including the sorting of plastics to avoid chlorinated plastic waste.
    - Carbon capture and storage from blast furnaces. The 3D project on the ArcelorMittal site in Dunkirk, which has already started in 2019, aims to validate a process developed by IFPEN to capture CO2 from steelmaking gas, with a demonstrator for an investment of €19.3M over 4 years with €14.8M in EU subsidies. A first industrial unit could be operational on the ArcelorMittal site in Dunkirk from 2026 and should capture around 1Mt CO2/year.

REDUCTION DRIVERS FOR THE ALUMINIUM SECTOR

In line with the “France 2030” plan recently announced, the aluminium employers’ association has launched a prospective study to reduce process emissions linked to the production of aluminium by electrolysis thanks to carbon capture technology, which is compatible with a breakthrough technology known as inert anode. The objective is to reduce direct emissions by 70% by 2030, to relocate the production and thus gain sovereignty and to create jobs.

While the aforementioned is only an intention, indeed the feasible target seems to be a reduction of direct emissions ranging from 55 to 105kt CO2e by 2030 compared to 2015, at constant perimeter. That will be carried out by:
• Improving control of the electrolysis process reducing anode effects, i.e. PIANO project, developed in the two R&D centres of Rio Tinto, LRF and Aluval, since 2018 aims to reduce emissions by 16%.

• Incremental reduction of emissions from aluminium processing and recycling from 6% to 9% by 2030 (€60 m to €100 m investment).

In the long-term, beyond 2030 main pathways include:

• Carbon capture and storage from electrolysis: the LRF and Aluval R&D centres are evaluating the possibilities.

• 100% reduction of process emissions from primary aluminium production by 2050: - 710kt CO2 assuming constant primary aluminium production. The Elysis JV between Rio Tinto and Alcoa explores since several years the breakthrough technology of the inert anode.

• The complete electrification of aluminium processing.

**REDUCTION DRIVERS FOR THE METALLURGICAL SECTOR**

The main player in non-steel metallurgical sector in France is Eramet which reached 246ktCO2e of emission volume in 2018.

The main short-term reduction drivers for this segment are:

• Electrification of heat treatment furnaces to produce special steel alloys;

• Substitution of carbon products in the feedstock (fluidisers) already underway;

• Replacement of 40% of the carbon reducers by bio-reducers (around 1M€ of estimated investment);

• Operational support for energy management using IoT and Big Data;

Regarding long-term reduction drivers, the Metallurgical Roadmap to decarbonisation points out:

• 700k€/year in research programmes with regards to: optimising the current process by improving the performance of the pre-reduction; development of new decarbonised processes such as the reduction of ores with renewable hydrogen and the electrolysis to produce Fe and Si Mn; the development and implementation capture capacities, transport and store of CO2 emitted by current production processes

• Decarbonisation of forging and heat treatment furnaces could be achieved through the generalisation of the electrification of furnaces and a greater use of biogas.
Main mature drivers for emission reduction for the chemical sector and its potential impact are listed in table 8.

### Table 8. Levers to reduce GHG emissions in chemical sector

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Reduction by 2030 compared to 2015 (MtCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mature technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>-1,8</td>
</tr>
<tr>
<td>Biomass heat</td>
<td>-1,4</td>
</tr>
<tr>
<td>Solid Recovered Fuel heat</td>
<td>-0,8</td>
</tr>
<tr>
<td>N2O</td>
<td>-0,8</td>
</tr>
<tr>
<td>HFC</td>
<td>-0,9</td>
</tr>
<tr>
<td>Total</td>
<td>-5,7</td>
</tr>
<tr>
<td>%</td>
<td>-26%</td>
</tr>
<tr>
<td><strong>Less mature technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Low carbon H2</td>
<td>-0,9</td>
</tr>
<tr>
<td>CCS</td>
<td>-0,4</td>
</tr>
<tr>
<td>Electrification</td>
<td>-0,3</td>
</tr>
<tr>
<td>Total</td>
<td>-1,6</td>
</tr>
<tr>
<td>%</td>
<td>-7%</td>
</tr>
<tr>
<td>Total levers</td>
<td>-7,3</td>
</tr>
<tr>
<td>%</td>
<td>-34%</td>
</tr>
</tbody>
</table>

Source: Roadmap for the chemical sector

A description of the processes and technologies required for each decarbonisation driver for chemical sector is detailed below:

- **Energy efficiency**: waste heat recovery and replacement of end-of-life equipment.
- **Biomass heat and SRF heat**: it will be necessary to perpetuate the support mechanisms launched by ADEME and to guarantee visibility on the availability of the fuel resource.
  - Other decarbonisation of industrial heat measures: self-consumption (i.e. on site) of biogas and solar thermal; connection of industrial plants to waste-to-energy plants.
- **N2O reduction**: duplication of facilities; new catalysis technologies.
- **HFC**: Hydrofluorocarbons are used in the refrigeration and air-conditioning, foams, aerosols and fire extinguishing equipment sectors. The aim is to develop new refrigerants with lower GWP (Global Warming Power) to replace high GWP HFCs.
- Low-carbon H2: The 2014 Pluriannual Energy Programme set an objective of achieving a 20 to 40% low-carbon hydrogen target in industrial hydrogen consumption in France by 2029. The assumptions for decarbonisation potential through low-carbon hydrogen production between 2015 and 2030 in the chemical sector represent 20%, 33% or 40% depending on different scenarios.

- CCS: There are research projects to apply these technologies to Val de Seine port area where are settled.

- Process electrification, through technologies such as mechanical vapour recompression; heat pumps and electric furnaces.

**ROADMAP FOR THE CEMENT SECTOR**

**Figure 27. Impact of carbon reduction levers in Cement sector (KgCO2/tn of cement)**

Main levers through decarbonisation in cement sector can be classified in 5 types:

- **Improving energy efficiency:**
  - Actions on processes (Potential GHG emission reduction: 0,33 Mt CO2 in 2030 and 0,44 Mt CO2 in 2050):
    - Transformation of cement processes by dry route through preheating and precalciner techniques.
    - Replacement of clinker furnace coolers with the latest technology coolers.
  - Electric energy efficiency (but no direct impact on GHG emissions)

- **Increasing the rate of substitution of fossil fuels by alternative fuels:**
  - Increasing the rate of alternative fuels containing biomass (Potential GHG emission reduction: 0,86MtCO2 in 2030 and 2050)
i. Fossil fuels are progressively replaced by energy waste such as oils, non-reusable used tyres, solvent and paint residues, energy liquids and RSC.

ii. In 2019, alternative fuels accounted for 41% of energy consumption.

- Increasing the share of biomass in fuels (Potential GHG emission reduction: 0,20MtCO2 in 2030 and 0,37MtCO2 in 2050):
  
  i. The aim is to increase the share of bio-based waste in alternative fuels.
  
  ii. The volumes of biomass in fuels should increase from 400Kt in 2016 to 1030Kt in 2030.

- Introducing new cements with a lower clinker content (Potential GHG emissions reduction: 1,1MtCO2 in 2030 and 1,7MtCO2 in 2050)
  
  i. The ratio cement/clinker should increase from 1,27 in 2019 to 1,4 in 2030 and 1,5 in 2050.
  
  ii. The carbon footprint is reduced by 50% compared to a Cem 1 (cement mainly composed of clinker) and by 35% compared to the average cement currently marketed.
  
  iii. Developing alternative cements (unquantified potential reduction) through innovations on new clinker obtained with lower firing temperatures than the current clinker.

- Capture, transport and storage or usage of carbon (Potential GHG emission reduction: 5MtCO2 in 2050); it is estimated that the first projects could be operational from 2025 onwards (which seems to be a very optimistic view).

### Table 9. Evolution of main production factors with an impact on the decarbonisation of cement sector

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>2015</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio cement/clinker</td>
<td>1.25</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Energy consumption of furnaces (MJ/Tck)</td>
<td>3 942</td>
<td>3 680</td>
<td>3 600</td>
<td>3 500</td>
</tr>
<tr>
<td>Substitution rate (alternative fuels/fossil fuels) (%)</td>
<td>38</td>
<td>65</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>Biomass share of alternative fuels (%)</td>
<td>49</td>
<td>50</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Volume of alternative fuels (kT)</td>
<td>1 050</td>
<td>1 500</td>
<td>1 800</td>
<td>1 800</td>
</tr>
<tr>
<td>of which CSR (kT)</td>
<td>272</td>
<td>1 000</td>
<td>1 000</td>
<td>1 000</td>
</tr>
<tr>
<td>Biomass share of CSR (%)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>CCS/CCU impact (drawdown ratio)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>70</td>
</tr>
</tbody>
</table>

Source: Roadmap for the mining and metallurgy sector

### 3.5. STRATEGIES OF MAIN ENTERPRISES TOWARDS DECARBONISATION

Most EIs have communicated their intentions to decarbonise their activities but only in few cases there are plans and strategies set out in documents or press releases. Against this context,
in most cases official communication only sets vague or general targets aligned with overall industry objectives with no indications on measures to be implemented to achieve the targets.

Only a few companies have developed concrete strategies and actions including precise emission reduction targets, but nevertheless most of them frequently do not announce concrete pathways to achieve them. A sample of some of these strategies can be found in ANNEX 1 which gives details of three companies in the non-ferrous metals, chemicals and cement sectors respectively.

Regarding announced or ongoing decarbonisation projects, a non-exhaustive list of the main projects in the four sectors analysed and the information published on them can be found in ANNEX 2.
#3
OVERVIEW OF POSSIBLE MEASURES TO BE ADOPTED IN ORDER TO MITIGATE/ MINIMIZE THE EMPLOYMENT IMPACT OF DECARBONISATION
4.1. MEASURES TO REDUCE DECARBONISATION IMPACTS ON EMPLOYMENT

With regard to the impact of decarbonization on EII employment, tasks, skills, and job profiles there is a widespread consensus on several facts as stated by the High-Level Group of Energy-intensive industries.50

The transition holds the potential to maintain the actual level of employment, but “abrupt disruption in the manufacturing processes may affect employment, most of the cases in remote areas affecting mainly blue collars”. This means that the transition can be carried out with the existing workforce, in terms of overall numbers but probably not with the same type of workers. The High-Level Group of Energy-intensive industries claims “the transition will require a major and sustained reallocation of labour across sectors, occupations and regions as well as significant investment in re- and up-skilling, retention of existing workers and attracting new workers.” 51 This implies that, although new workers with the right skills will enter the labour market, there will be a need for massive retraining of existing workers, without which the transformation of the industry cannot be successful.

According to the masterplan drafted by the High-Level Group of Energy-intensive industries, skills development will be a particularly important challenge as new capacities will be necessary, mainly in terms of digitalisation, decarbonisation, innovation, internationalisation, and resilience. But an important role is also to be played by the “key competences” or “21st century skills” or even “soft skills”. The next challenge will be to combine the improvement and adaptation of basic and digital skills with the development of cognitive and socio-emotional skills (problem solving, creativity, communication and collaboration). Furthermore, the High-Level Group include STEM subjects, that is, science, technology, engineering, and mathematics.

High demand is forecast for engineers, specialists and business professionals who have emerging technology expertise. On the other hand, new job opportunities can be expected in design, innovation and product development, disassembling, remanufacturing, repair, administrative handling of new service contracts, resource scouting and information management52.

That being said, in order to minimize the impact of decarbonisation on employment either from a quantitative point of view (volume of workers) or from a qualitative point of view (quality of jobs, type of skills to be developed...), a variety of policies/mechanisms/tools can be developed at European, national and company level.

These tools range from European mechanisms aimed at strengthening the competitiveness of European industry (Carbon Border Adjustment Mechanism - CBAM) to company policies aimed

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50 “Masterplan for a Competitive Transformation of EU Energy-intensive Industries Enabling a Climate-neutral, Circular Economy by 2050”


at identifying existing and future jobs and skills (current and prospective mapping of jobs and skills) without forgetting the role of public authorities when designing public policies and programmes for vocational training.

4.2. WHICH ROLE FOR THE CBAM?

CARBON BORDER ADJUSTMENT MECHANISM

The European strategy on climate neutrality has moved forward with the publication of EU Regulation 2021/1119, called the "European Climate Law", on July 2021; this regulation sets the framework for achieving climate neutrality and it formally enshrines in EU law the new binding target of reducing the EU’s net greenhouse gas (GHG) emissions by at least 55% between 1990 and 2030 (previously 40%) and the collective binding target of carbon neutrality (or zero net emissions) in the EU by 2050. The new political and legislative package (13 proposals for measures known as Fit for 55) was published on 14 July 2021, its main aim is to put these new objectives into practice. Fit for 55 introduces a combination of pricing measures, targets, standards, and support. One of the areas developed is the revision of the EU ETS directive and its emissions allowance system (accelerating the reduction of free allocations). On the other hand, there is a regulation establishing a Carbon Border Adjustment Mechanism (CBAM) to combat carbon leakage and push other EU trading partners to adopt new climate targets and instruments.

The CBAM project provides for the creation of a mechanism mirroring the EU ETS carbon market, i.e. the establishment of a price for carbon equivalent to the price of ETS emissions allowances for imported products. The companies concerned will have to surrender CO2 emission certificates (or CBAM certificates) according to the carbon intensity of imported products. The certificate price will be aligned with the price of ETS allowances. For this system to be monitored, companies will have to declare their imports to a competent national authority.

The draft regulation provides for a mechanism modelled on the Emissions Trading Scheme (ETS) for importers to the EU. In an initial phase, imports of iron and steel, aluminium, electricity, and fertilisers were selected to be covered by the CBAM, as they account for 55% of the emissions at risk of carbon leakage.

The project plans full implementation of the CBAM from 2026. In a transitional stage (01/01/2023-31/12/2025), importers in the four selected sectors will have to report the CO2 emissions contained in their products as well as the carbon price they have already paid (or not) abroad.

One of the challenges will be to determine the carbon content of an imported product and thus facilitate the exchange of information on the production process between third countries and the EU.

In order to avoid European companies being doubly protected from carbon leakage, the allocation of free allowances should be phased out by a 10% reduction each year during a period of 10 years. To be WTO compatible, the EU will not be able to offer double protection to the pre-selected sectors as the WTO has already organised exchanges between the European Commission and its main trading partners. The phasing out of free allowances as a prerequisite
will force the industries concerned to pay for their emission allowances in order to continue their activity or implement action plans to reduce their emissions.

Table 10. Exporting countries of products potentially covered by CBAM and their share in European imports by sector\(^{53}\)

<table>
<thead>
<tr>
<th>SECTORS COVERED</th>
<th>Cement (European consumption from imports: 2.6%)</th>
<th>Fertilisers (European consumption from imports: 29.5%)</th>
<th>Iron and steel (European consumption from imports: 19.7%)</th>
<th>Aluminium (European consumption from imports: 36.6%)</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Turkey: 34%</td>
<td>Russia: 31%</td>
<td>Russia: 15%</td>
<td>Norway: 18%</td>
<td>Switzerland: 27%</td>
</tr>
<tr>
<td>2</td>
<td>Colombia: 8%</td>
<td>Egypt: 9%</td>
<td>Turkey: 11%</td>
<td>Russia: 14%</td>
<td>Norway: 18%</td>
</tr>
<tr>
<td>3</td>
<td>Ukraine: 7%</td>
<td>Belarus: 8%</td>
<td>Ukraine: 10%</td>
<td>China: 9%</td>
<td>Russia: 13%</td>
</tr>
<tr>
<td>4</td>
<td>Belarus: 7%</td>
<td>Algeria: 8%</td>
<td>China: 8%</td>
<td>United Arab Emirates: 7%</td>
<td>Ukraine: 7%</td>
</tr>
<tr>
<td>5</td>
<td>Bosnia-Herzegovina: 4%</td>
<td>Morocco: 7%</td>
<td>South Korea: 8%</td>
<td>Switzerland: 7%</td>
<td>Bosnia-Herzegovina: 6%</td>
</tr>
</tbody>
</table>

At this stage, only direct emissions are covered by CBAM i.e. only scope 1 of EII carbon footprint is taken into account. Electricity (scope 2, which extremely determines the carbon footprint of EAFs and DRIs) and transport (including in scope 3) are not yet concerned by the mechanism. Nevertheless, EII will have to communicate their emissions regarding scope 2 from 2023 to 2025 but their integration into the CBAM has not yet been decided. They may be included in a second stage. Scope 3 might eventually be considered for so-called complex goods in two different approaches. First, CBAM might include upstream emissions, when they represent the largest share of the carbon footprint of these products. Besides, future revisions to the mechanism could include transport-related emissions.

There are pros and cons regarding scope 2 and electricity. The risk of resource shuffling is especially pinpointed by some industrial actors. Resource shuffling is a strategic decision by players which choose to export the lowest carbon-intensive portion of their production to markets with high carbon costs (for instance, Europe) and use high carbon footprint products in their national market or in regions concerned with less expansive carbon market. With resource shuffling there is a risk that for specific industry some carbon leakage could be favoured.

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\(^{53}\) Source: ERCST, Border Carbon Adjustments in the EU: Sectoral Deep Dive, 2021
The share of carbon-free production at the global level may not change. Imports into Europe would take precedence over local production without exporting countries having decarbonised additional assets.\textsuperscript{54}

Thus, this risk is present when the mechanism relies on actual emissions at the level of an installation rather than for instance on national energy mix. This effect is extremely difficult to assess. Modelling has been made by the European Commission as part of the impact assessment report. The existence of resource shuffling would lead to a carbon leakage rate of 13% in the cement sector, 8% in the aluminium sector minimal for the European steel sector.

The European electricity market can also be considered as a disadvantage for European REEIs because prices are calculated according to a merit order based on variable costs. If the last source called is carbonised (e.g. gas or coal) then the carbon price included in electricity does not represent the local mix or the real carbon footprint of the sources of electricity used by an industrialist/manufacturer. It must be noticed that REEIs usually benefit from complex contracts and thus are not totally exposed to the electricity gross market. They can also benefit from indirect compensations. For the moment, however, their renewals trough the CBAM context are uncertain.

More generally, electricity prices (level, volatility etc.) in Europe can be a source of risks for actual and future REEIs.

**THE POTENTIAL IMPACT OF THE CBAM: THE FOREIGN TRADE OF ENERGY-INTENSIVE SECTORS IN FRANCE**

The international trade analysis for the EII sectors in France enables an assessment on the possible impacts of the application of the CBAM system.

According to Eurostat foreign trade data in terms of tonnage, we observe that iron and steel imports from non-EU countries were limited in 2020 to 9% of total imports. The extra-EU external balance of iron and steel remains positive for France, although it is far from the 2.8kt

\textsuperscript{54} This risk exists particularly in the primary aluminium industry regarding Chinese production, in which 15% is based on hydro-electric process. This more decarbonised aluminium could first serve the European market, which could eventually lead to new closures in Europe while the rest of the carbon-based capacity would serve the local Chinese market (or other exports). In this case, the CBAM would not have led to transforming high carbon footprint capacity towards carbon reduction in Europe or globally.
surplus reached in 2014. Main extra-EU countries exporting iron and steel to France in 2019 were: Russia (1.6% of total iron and steel imports in France), followed by Turkey (0.9%), Brazil (13.3%), Brazil (0.7%), Switzerland (0.7%), China (0.6%), USA (0.5%) and South Korea (0.4%).

The distribution of imports of chemicals, plastics and rubber is more balanced. Currently, 60% of this type of imports comes from within the EU while 40% comes from countries outside the EU. There is a permanent deficit in the external balance with respect to the countries outside EU that has been reduced in the last year to achieve its best result in years. France imported chemical products in 2019 mostly from the following extra-EU countries: USA (5.4% of total chemical imports), Switzerland (5.2%), China (3.4%), Japan (1.3%), India (0.9%) and Singapore (0.8%).

Regarding cement and lime imports in France, 20% of them come from outside the EU. The trade balance with respect to extra-EU countries, always in negative figures, registered a deficit in 2020 that has been steadily worsening since 2017 to reach one of the worst levels in 15 years. In 2019 France imports cement products from the following extra-EU countries: Colombia (4.3% over total cement imports in France), Morocco (1.9%), Vietnam (1.6%), Saudi Arabia (1.2%), Malaysia (0.9%) and Turkey (0.7%).

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55 ATLAS of Economic Complexity by the Growth Lab at Harvard University https://atlas.cid.harvard.edu/
Regarding aluminium foreign trade, 25% of aluminium imports of France come from countries outside EU. The aluminium trade balance with extra-EU countries, always in deficit, swung sharply between 2008 and 2012 and started to fall progressively from 2013 to 2019. A sharp drop in imports in 2020, mainly caused by the pandemic, has led to a reduction in aluminium deficit with respect to countries outside EU. In 2019 aluminium was imported in France mainly from the following extra-EU countries: China (4.8% of total aluminium imports), Switzerland (3.8%), USA (2.7%), Russia (2.2%), Norway (2.2%), Turkey (1.9%) and United Arab Emirates (1.5%).

The CBAM implementation in France would mainly have impacts on chemical sector as this is the sector with the highest imports weight from outside EU over total imports in its sector, 40% in 2020. Regarding fertilisers, where the exporting countries potentially covered by CBAM are Russia, Egypt, Belarus, Algeria and Morocco, we found that all of them are precisely between the extra-EU most important fertilisers’ exporters to France in 2019: Russia (5.7%), Egypt (5.3%), Morocco (4.4%), Algeria (3.8%) and Belarus (2.7%).

Aluminium is the second EI sector in terms of highest extra-EU imports ratio, accounting for 25% of total aluminium imports in France. The countries targeted by CBAM EU project in this regard could be: Norway, Russia, China, UAE and Switzerland, and all of them are between the most important exporters of aluminium products in France, specially China and Switzerland.

Weight of extra-EU imports is also important in cement sector in France, supposing 20% of total cement imports. The exporting countries potentially submitted to the CBAM mechanism are Turkey, Colombia, Ukraine, Belarus and Bosnia-Herzegovina. Two of them are between the most important extra-EU cement exporters to France: Colombia and Turkey.

The impact of the CBAM mechanism on the French steel sector would be less important than the impact on the chemical, cement and aluminium sectors, due to the lower percentage of steel imports from outside the EU (9% of total steel imports in 2020). Russia, Turkey, Ukraine, China and South Korea are the targeted countries by the possible implementation of CBAM mechanism by EU. Russia, Turkey, China and South Korea are important exporters to France of steel products.

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56 ATLAS of Economic Complexity by the Growth Lab at Harvard University [https://atlas.cid.harvard.edu/](https://atlas.cid.harvard.edu/)
Taking into account all these considerations, the potential impacts of the implementation of the CBAM are not negligible for France, especially given the fact that there is a historical trade deficit for 3 of the 4 energy-intensive sectors analysed: aluminium, chemicals and cement.

For the CBAM to be effective and lead to a re-industrialisation in the country of the most affected sectors mentioned above, it needs to be complemented by measures to ensure its effectiveness. Measures that seek to mitigate the risks associated with the difficulty of verifying emissions\(^\text{57}\), the above-mentioned risk of resource shuffling or a possible restructuring of the value chain.\(^\text{58}\)

Another major challenge will be to ensure the economic viability of the sectors’ decarbonisation projects while gradually reducing quotas each year. If there is no alignment between the two processes, there would be a risk of loss of competitiveness in international markets of long-term deindustrialisation, rather than reindustrialisation.

In the face of these challenges, measures such as Carbon Contracts for Difference\(^\text{59}\), investment aids and measures to accelerate the decarbonisation of countries’ energy mixes are essential.

Although in some sectors, such as steel, the weight of extra-EU imports is not very high, in other sectors it is clearly significant and the repercussions in terms of increasing national or EU production activity and preserving employment could be significant.

### 4.3. THE ROLE OF PUBLIC POLICIES AIMING TO MITIGATING THE EMPLOYMENT IMPACT OF DECARBONISATION

A just transition for all workers concerned by EII pathways to decarbonisation requires a strong public policy adapted to the needs of enterprises and workers. The French government has developed plans to promote professional transition and reconversion of workers.

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\(^{57}\) Where emissions cannot be verified, the EC proposes to use default averages (an average of the emissions of the exporting country, or an average of the top 10% of emitters within the EU). This could result in non-European producers emitting above that average benefiting and receiving no incentive to reduce their emissions, but just the opposite, with even producers at or just above that average increasing their emissions (by producing more, for example) to have a greater margin.

\(^{58}\) Enforcement only on some basic materials sectors may create a shift from imports to manufactured products. This could harm local manufacturing industries.

\(^{59}\) This instrument facilitates investments in breakthrough technologies by offsetting its additional operating costs and it also reduces the risk of long-term investments. CCFD will be key policies and will be included in the coming ETS directive. The higher the price of carbon, the less expansive these contracts will be. But they can be an answer to sharp downward cycles which can threaten the carbon reduction process. This kind of contracts already exist for renewable energy. They are promising financial tool because they allow both access to financial resources and they reduce the risk faced by industrial while considering decarbonisation projects. They can answer to one of the most important weaknesses of the ETS carbon market: carbon price versality can delay or even threaten investment. In fact, this system would be somewhat similar to “feed-in- premium/tariff” (FIP/FIT) policies for renewable energy projects to be “investible”. They will guarantee producers a fixed carbon price, which will be in fact the abatement cost of the technology compared to the current CO2 price. If the carbon price were higher than the guaranteed price, there would be no payment.
With over €15 bn budget, the French Skills Investment Plan\(^{60}\), established for five years (2018-2022), aims to upskill jobseekers with a focus on young and least qualified population, by providing vocational trainings, improving training schemes and training conditions and prioritising the strengthening of digital skills and jobs for the future. The challenges to be addressed are:

- Training for 1 million low-skilled/unskilled jobseekers and 1 million young people furthest away from the labour market, in particular people with disabilities and those living in urban policy priority neighbourhoods and rural regeneration areas;
- Meeting the needs of companies facing recruiting difficulties;
- Contributing to the skill-related process of transformation, particularly in light of the digital and green transitions.

Although the French Skills Investment Plan has a national scope it is implemented on a regional scale (by regional councils), as part of the Regional Skills Investment Pacts (2019-2022, after an initiating phase in 2018), taking into account the specificities of each region (Pôle emploi is particularly involved in two regions: Auvergne-Rhône-Alpes and Provence-Alpes-Côte d’Azur).

France has identified areas for improvement in the coming years in terms of employment, skills and competences, thanks to France Stratégie’s 2017-2027 project, also known as the Pisani-Ferry report\(^{61}\), setting out a broad investment plan with 4 priorities for the 2017-2027 period to ensure France’ sustainable growth dynamic. With €57 bn total budget, its main development axes are:

- Accelerating the green transition (€20 bn);
- Building a society of skills (€15 bn);
- Rooting competitiveness in innovation (€13 bn); and
- Building the state of the digital era (€9 bn).

In addition, the plan is included in the vocational training reform and complements the “law on the freedom to choose one’s professional future”\(^{62}\) of September 2018.

The National Low Carbon strategy points out the following tools and support actions exist in favour of professional transitions and reconversions linked to the energy and climate transition:

- The "employment and skills programming plan" (PPEC)\(^{63}\), which concerns only the energy sectors and takes into account the guidelines set by the Multi-Annual Energy

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60 Le Plan d'Investissement dans les Compétences  
https://dares.travail-emploi.gouv.fr/sites/default/files/9d80ee925557c938ff1416da9a5872ef/Rapport%20CS.pdf  
61 http://francestrategie1727.fr/  
62 https://www.legifrance.gouv.fr/dossierlegislatif/JORFDOLE000036847202/  
Plan for continental metropolitan France (cf. energy transition for green growth act of 17 August 201564)

- The Regional Economic Development, Innovation and Internationalisation Scheme (SRDEII) sets out the Regions’ strategic economic guidelines;
- The CTEs (ecological transition contracts), which set out with environmental, economic and social issues in a global approach by involving local authorities and companies;
- The trials, mostly at regional level, such as the deployment in four regions of France of the Methodological kit to support professional transitions in sectors impacted by the energy and ecology transition, to develop potential professional careers
- The GPEC65 system (see final chapter); the GPEC methodology should facilitate a collective understanding of employment and skills issues and the construction of cross-cutting solutions that simultaneously respond to the challenges of all the actors concerned: companies, territories and the workforce.
  - The government supports the prospective skills actions in the occupational fields through the Skills Investment Plan.66
- As part of the Skills Investment Plan, the co-financing by Pôle emploi (the French public employment service) of 10,000 training courses for jobs in the ecological transition.

The national strategy on employment, skills, qualifications and occupational training regarding to decarbonisation is based in two guidelines:

- Encourage better integration of the low carbon transition challenges by industrial sectors, businesses and territories in order to facilitate occupational transitions and conversions and developing future employment.
  - Develop, at both national and territorial levels, tools for analysing changes in jobs and skills linked to the energy and climate transition, as well as support and adaptation actions to bring stakeholders together, such as the employment and skills programming plan, ecotransition contracts, experiments and GPEC (Forward planning of employment and skills plans) actions.
  - Support a renewal of the skills needed for energy and climate transition in all sectors of activity, notably in the economic channels most affected by the low carbon transition in their “core profession”, particularly the building sector, the channels linked to the development of the bioeconomy, the mobility sector and the energy production channels (cf. Multi-Annual Energy Plan in mainland France and the Skills and Employment Programming Plan).

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64 https://www.gouvernement.fr/en/energy-transition#:~:text=and%20energy%20efficiency.,The%20Act%20of%2017%20August%202015%20on%20energy%20transition%20for,order%20to%20boost%20green%20growth
• Adapting formal education and continuing education systems in order to support the transformation of activities and territories
  o Initiate and inform a revision of professional diplomas and certificates, with the objective of better incorporating the changing skills requirements in teaching programmes (including in agricultural and forestry teaching), as well as in the range of further professional training programmes available (including training for elected officials), so that the skills available match the requirements of the businesses and regional authorities involved and the requirements of the ecology and climate transition.
  o To enable the preceding point, provide a skills base to teachers and trainers to allow them to integrate low carbon transition issues in their teaching.
  o Undertake specific actions for the voluntary sectors, such as setting up a certification of energy contact points in industry and their registration in the National Directory of Professional Certifications (NDPC).

4.4. MECHANISMS TO BE IMPLEMENTED BY COMPANIES IN ORDER TO MINIMIZE THE IMPACT OF DECARBONISATION ON EMPLOYMENT, COMPETENCES AND SKILLS OF THE WORKFORCE

The decarbonisation transformation will require a profound reorganisation of the EII sector and an in-depth reflection on the needs in terms of workforce but also of skills required to carry out the future activities.

In France the legal framework sets up a range of obligations on the issue of the “management of jobs and professional careers”:
  o In national companies of at least 300 workers or in international companies having at least 150 workers in France, a collective bargaining between the employer and the workers’ representatives must take place at least each 4 years on the issue of “the management of jobs and professional careers”67
  o Whenever there is no such agreement at company level in national companies of at least 300 workers or in international companies having at least 150 workers in France, the employer must organise “every three years, in particular on the basis of the strategic orientations of the company and their consequences..., a negotiation on the management of jobs and career paths and on the job mix concerning:
    o The implementation of a system of forward-looking management of jobs and skills, as well as the accompanying measures likely to be associated with it, in particular in terms of training, ..., the validation of acquired experience, skills assessment as well as support for the professional and geographical mobility of employees...”68

67 Article L2242-2 Code du Travail
68 Article L2242-20 Code du Travail
The fulfilment of such legal obligation sets the frame to implement, at company level, a prospective policy aiming at analysing the actual and future skills and defining the future jobs and skills. The mechanism allowing the implementation of this prospective policy is called “Gestion Prévisionnelle des Emplois et des Compétences -GPEC-” and it involves, as seen below, a multiplicity of factors and stakeholders.

**Figure 36. Diagram of the job and competence planning system in France (GPEC): actors, stages and interrelation between them**

The methodology used to implement an accurate GPEC should follow the following scheme:

**IDENTIFYING AND ANALYSING THE ACTUAL SITUATION**

This step involves several sub-steps:

- draw up a cartography of jobs and qualification,
- carry out a complete diagnosis of jobs and skills,
- carry out a diagnosis of the tools already used by the human resources department to assess jobs and skills,
- analysing the company's development forecasts and identifying its needs
- defining the tools to be implemented to support the GPEC approach: professional interviews, skills assessments, training actions, validation of acquired experience (VAE), new work organisation, mobility, etc.

During this step the key point is the correct definition and cartography of existing jobs.
By means of this cartography it is intended to identify the trends to which jobs are exposed:

- **in tension**: requiring strategic and rare skills. Need to recruit very specific profiles
- **undergoing transformation**: the content or methods of work require new skills (digitalisation of work content, changes in the way the activity is carried out)
- **emerging or growing**: requiring the creation of new jobs in the short or medium term
- **in decline**: exposed to a reduction in the number of employees or to disappearance
- **stable**: no particular changes expected

Employees must have an upstream vision of future developments of jobs and position and of the possible links between each, in order to be able to anticipate and build their careers.

**CARRYING OUT A PROJECTION OF FUTURE JOBS AND SKILLS IN ORDER TO MEASURE THE GAPS WITH THE EXISTING SITUATION**

- **Growing activity, the trend will continue in the medium term**
  - Hirings, internal transfers or even replacement of fixed-term contracts by permanent contracts are possible.
  - But other potential evolutions (ex. digitalisation) must be taken into account to check whether changes in the production won’t have an impact on employment.

- **Strong activity, but it won’t last**
  - The issue of securing professional paths of the whole workforce (including fixed-term or temporary workers) is raised.
  - The work to prepare the future starts now.

- **Stable activity**
  - Behind a stable situation, there are always potential upcoming changes: people leaving to be replaced. Stable production but with fewer workers.
  - In this case, the jobs must be clearly identified.

- **Downturn in business**
  - The issue of the progressive reconversion of workers is raised but also of their dismissal.
  - Two factors in order to assess the deadline to act: the downturn rythme and the time when the size of the company would be considered as being critical.

- **The business is doomed**
  - Needed up/re-skilling of workers in order to guarantee their employability.
DEFINITION OF AN ACTION PLAN: RECRUITMENT, TRAINING, UP AND RE-SKILLING, MOBILITY, WORK ORGANISATION, ETC.

Figure 37. Main potential tools to apply for job and competence planning

Different tools can be used to implement a GPEC

SETTING UP KPIS IN ORDER TO ANALYSE AND ASSESS THE ACTION PLAN

Together with the setting up of relevant KPIs aiming at assessing the effectiveness of the action plan and in order to involve workers representatives as much as possible in the whole process, a joint institution may be created in order to assess and anticipate the upcoming trends of jobs and professions.

The objectives of this institution could be, between others:

- Mapping and highlighting the employment situation in the various professions/jobs (ages, locations, skills, etc.)
- Identifying the possible bridges between the professions
- Anticipating social developments linked to changes in the environment and the company's or group's industrial projects
- Carrying out workforce's volumes forecasts (on the basis of scenarios if necessary)
- Identify up/re-skilling processes to answer to changes in the professions/jobs
- Facilitating and monitoring the implementation of solidarity between the companies active in the same geographical zone

A right use of the possibilities given by the law and a right implementation of the GPEC mechanism can guarantee:

- A good analysis of the actual and future situation of the company in terms of workforce and skills
- The design of the most accurate action plans aiming at adapting the workforce to the challenging and changing environment
- The achievement of a fair transition involving as fewer negative impacts as possible
#4 CONCLUSIONS
After what is known as the first great transformation of industry in the 1970s, today’s industry, and therefore EII companies, are immersed in a new great transformation caused by a combination of, inter alia, different factors such as the internationalisation of markets and raw material flows, the booming industrial position of emerging countries and geographical areas, especially the predominant role of China or the technological revolution and digitalisation applied to industrial processes.

To all these factors we can add, as a final and fundamental guest, the concern for climate change, always neglected in previous decades, which, especially since COP 21 in Paris and as a result of the increasingly loud and widespread voices of civil society, has led to a generalised state of awareness that has finally provoked a reaction from political bodies, employers’ organisations and companies.

Against this context, the French authorities have, since 2005, taken different steps to safeguard as much as possible the EII and today the national decarbonisation and the journey to zero-carbon seeks to address the challenges faced by the EII.

The National Low-Carbon Strategy, revised in 2020, and the Roadmaps for the metallurgy, chemical and cement sector published in 2021, define the national decarbonisation objectives and develop the paths to achieve them and as a positive point, these roadmaps and strategies are backed up by a good number of governmental aids ranging from decarbonization funds or aids to produce energy through biomass or SRF to programs to promote energy efficiency, electrification and adaptation of processes or aids to ambitious projects coming from Industrial Recovery Plan.

However, several criticisms can also be made either from a methodological or a technological point of view. As a matter of fact, and from a methodological point of view, the roadmaps seem to compile the initiatives and projects reported by individual companies, rather than constituting a tool designed by government, industry and trade unions that takes into account the national reality of the sectors or the possible synergies between research, technologies and companies. Regarding technology, the feasibility of several pathways (namely hydrogen and CCUS) is still under discussion (not to mention the financial issues of these two breakthrough technologies).

But the main criticism relates to the way in which the social issues of decarbonisation are dealt with; in fact, the decarbonisation impact on employment and skills is scarcely mentioned although some initiatives on vocational training may be found here and there.

Against this lack of visibility on the quantitative impact of the decarbonisation, the ability of enterprises to adapt and upgrade the competencies and skills of their workforce to new technologies or production processes will play a key role in the job preservation. In this respect there is a widespread consensus that a successful transition will require a major and sustained reallocation of labour across sectors, occupations and regions as well as significant investment in re- and up-skilling, retention of existing workers and attracting new workers. Given this requirement, skills development will be a particularly important challenge as new capacities will

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69 In 2005 came into force the legislation recognising the legal status of energy-intensive industries with set a favourable frame with regards to the access to electricity and the financing of the high energy consumption of the EII.
be necessary. Digitalisation, decarbonisation, innovation, internationalisation, resilience... All these factors affect the organisation and industrial production but also the skills required for workers, that not only include technical or digital skills but also cognitive and socio-emotional ones. The development of “key competences”, “21st century skills” combined with “soft skills” such as resilience, creativity, critical thinking, flexibility, teamwork, decision making...

In the coming years a high demand for engineers, specialists and business professionals -who have emerging technology expertise- is forecast. Also new job opportunities can be expected in design, innovation and product development, disassembling, remanufacturing, repair, administrative handling of new service contracts, resource scouting and information management.

Together with adequate mechanisms of up and reskilling promoted at national, sectoral or company level, there are other general mechanisms that can help to minimise the potential impact of decarbonisation on employment. One of them is the CBAM which if correctly implemented can preserve European industrial competitiveness and employment.

A right combination of all the aforementioned tools will be key to safeguard employment and skills in the EIs.
EXAMPLES OF DECARBONISATION STRATEGIES COMMUNICATED BY MAJOR PLAYERS IN THE CHOSEN SECTORS

STAINLESS STEEL

APERAM

The group Aperam is a global player in the stainless, electrical and specialty steel market with 6 production sites: 3 in France (Isbergues, Imphy and Gueugnon), 2 in Belgium (Genk and Châtelet) and 1 in Brazil (Timoteo).

Its European EAFs use already over 80% of scrap and the group is working on further increasing its scrap intake. The group also use a low-carbon energy mix in its French and Belgium melting shops.

CO2 footprint of the group has been constantly below 0.5 tons of CO2 per ton of crude steel produced, from 0.55 in 2015. In 2020, the group achieved a 35% reduction in intensity versus 2007. With 2020 Scope 1 and Scope 2 emissions of 666,372 and 255,665 kg CO2 in absolute value, Aperam reduced its total CO2 emissions (scope 1+2) by 5% over 2019, which represents a 14% decrease in intensity since 2015.70

<table>
<thead>
<tr>
<th>Main Aperam indicators and targets on environmental performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicator</strong></td>
</tr>
<tr>
<td>Energy Consumption: Elec./Nat. Gas/LPG</td>
</tr>
<tr>
<td>Energy Consumption: All</td>
</tr>
<tr>
<td>CO2 emissions (Scope 1+2)</td>
</tr>
<tr>
<td>Dust emissions (exhaustive assessment)</td>
</tr>
<tr>
<td>NOx Emission (Europe)</td>
</tr>
<tr>
<td>SOx Emission (Europe)</td>
</tr>
<tr>
<td>Recycled input in Production</td>
</tr>
</tbody>
</table>

The group has just revised and restructured its CO2 roadmap and its financing envelope to meet 2030 and 2050 targets. This new program is based on 7 key projects: energy Efficiency, carbon-free fuel, change in raw materials mix, heat recuperation, solar and wind energy supply, green Electrical Energy sourcing and Carbon Capture /Utilizations to close the gap for CO2.

CHEMICALS

SOLVAY

The commitment of the chemical group announced in September 2018 was to reduce at least 1Mt CO2 emissions by 2025 compared to 2017 level, at constant scope.

71 Source: Aperam.
In February 2020, Solvay launched a new 2030 sustainability program, Solvay One Planet, as part of its G.R.O.W strategy focused on growth, cash and return on investments. The program sets out ten targets on better climate, resources and social performance. The targets were further revised in 2021 and validated by Science-Based Targets initiative (SBTi):

- 30% of emissions reduction target (from -26% initially) by 2030 and carbon neutrality before 2050, aligning its trajectory with the “well below 2°C temperature increase” goal outlined in the 2015 Paris Agreement.

- Eliminating the use of coal: Solvay will not build new coal-powered plants and commits to phase out coal usage in energy production wherever renewable alternatives exist.

CEMENT

HOLCIM

The cement and aggregates production group resulting from the merger between the Swiss Holcim and the French Lafarge has recently launched “Net-Zero Journey” strategy\(^2\), by which they set out their decarbonisation targets among other climate action plans.

In 2020, Holcim committed to accelerate its reduction in CO2 intensity to exceed 20% (compared to 2018 baseline) and it was the first global building materials company to sign the UNGC’s “Business Ambition for 1.5°C” initiative, with intermediate 2030 targets approved by the SBTi in alignment with a net-zero pathway.

In October 2021, the group further reviewed their commitments for 2030 and 2050, scaling up and accelerating the available levers and deploying next-generation technologies (including novel binders, zero-emission vehicles, low-clinker cements and Carbon Capture Utilization and Storage):

- Reduction of scope 1 and 2 GHG emissions by 95% per ton of cementitious materials by 2050 from a 2018 base year (the target boundary includes land related emissions and removals from bioenergy feedstocks)

- Reduction of scope 3 GHG emissions by 90% by 2050 from a 2020 base year.

## Holcim Net-Zero targets by scope

<table>
<thead>
<tr>
<th>YR</th>
<th>SCOPE 1</th>
<th>SCOPE 2</th>
<th>SCOPE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>576 BASELINE</td>
<td>38 BASELINE</td>
<td>29 MT BASELINE</td>
</tr>
<tr>
<td>2022</td>
<td>555</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>475 kg CO₂eq/tonne cement</td>
<td>13 kg CO₂eq/tonne cement</td>
<td>-20% kg CO₂ per ton of purchased clinker and cement</td>
</tr>
<tr>
<td>2030</td>
<td></td>
<td></td>
<td>-20% kg CO₂ per ton of purchased fuels</td>
</tr>
<tr>
<td>2050</td>
<td></td>
<td></td>
<td>-24% kg CO₂ per ton of cement transportation</td>
</tr>
</tbody>
</table>

Gross emissions across the value chain validated by [SCIENCE-BASED TARGETS](#).

Source: Holcim
ANNEX 2
### Main decarbonisation projects of EII under development or already in operation in France

#### Steel sector

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Project</th>
<th>Budget (€)</th>
<th>Description</th>
<th>Target</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcelorMittal</td>
<td>Fos-sur-Mer</td>
<td>Decarbonisation of steelmaking</td>
<td>1.7 bn</td>
<td>Construction of EAF complementing the ladle furnace announced March 2021.</td>
<td>CO2 reduction by 40% or 7.8 Mt per year</td>
<td>operating by 2027</td>
</tr>
<tr>
<td>ArcelorMittal</td>
<td>Dunkirk</td>
<td>IGAR Hybrid HF3</td>
<td>-</td>
<td>Recirculation of reducing steelmaking gases from the coking, steelworks and blast furnace processes, in three stages.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ArcelorMittal</td>
<td>Fos-sur-Mer</td>
<td>Carblyst</td>
<td>120 M</td>
<td>Implementation of technologies involving gas-fermentation technics using microbes to convert waste gases into advanced bioethanol for use in transport and to make plastics.</td>
<td>350 Kt of CO2 reduction</td>
<td>2030</td>
</tr>
<tr>
<td>ArcelorMittal</td>
<td>Fos-sur-Mer</td>
<td>Torero</td>
<td>55 M</td>
<td>Pyrolysis of biomass and waste at low temperature to produce renewable energy in form of biocoal, biofuels, biogases.</td>
<td>2030</td>
<td>-</td>
</tr>
<tr>
<td>ArcelorMittal</td>
<td>Fos-sur-Mer</td>
<td>CarbHFlex</td>
<td>-</td>
<td>Implementation of a process that uses microbes to produce acetone and isopropanol, both basic chemicals used to make plastics.</td>
<td>-</td>
<td>operating by 2026</td>
</tr>
</tbody>
</table>

#### Aluminium sector

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Project</th>
<th>Budget (€)</th>
<th>Description</th>
<th>Target</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>RioTinto</td>
<td>Voreppe</td>
<td>PIANO project</td>
<td>-</td>
<td>Improving control of the electrolysis process reducing anode effects.</td>
<td>GHG emission reduction by 16%</td>
<td>operating since 2018</td>
</tr>
</tbody>
</table>

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73 Source: Elaboration by Syndex, based on companies' investors reports.
### Main decarbonisation projects of EII under development or already in operation in France Chemicals sector

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Project</th>
<th>Budget (€)</th>
<th>Description</th>
<th>Target</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exxon</td>
<td>Area of Axe Seine/Normandy</td>
<td>CCS projects</td>
<td>-</td>
<td>To explore the development of a CO2 infrastructure, including capture and storage, to help decarbonize the industrial basin located in the region.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>CO2 emissions reduction up to 2030 3 Mt/year</td>
<td></td>
<td></td>
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<tr>
<td>Borealis</td>
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<tr>
<td>Air Liquide</td>
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</table>

### Main decarbonisation projects of EII under development or already in operation in France Cement sector

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Project</th>
<th>Budget (€)</th>
<th>Description</th>
<th>Target</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deutsches Zentrum Fur Luft, Abengoa Research SI, Manchester University and other</td>
<td>-</td>
<td>SC Solpart project</td>
<td>-</td>
<td>Pilot plant aiming at supplying totally or partially the thermal energy requirement for CaCO3 calcination by high temperature solar heat.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Armines, Vicat and other</td>
<td>France, Germany, Belgium, Netherland and UK</td>
<td>EU Interreg CIRMAP</td>
<td>€6.98 M (all countries)</td>
<td>Reusing Recycled Fine Aggregates in order to manufacture Urban, Memorial of Garden (UMG) furniture</td>
<td>-</td>
<td>until 2023</td>
</tr>
<tr>
<td>SNBPE, Saint-Gobain, UNPG</td>
<td>Crechy</td>
<td>Fastcarb</td>
<td>-</td>
<td>To store CO2 in the RCA (Recycled concrete aggregate), while improving the quality of this aggregate by plugging the porosity and ultimately reducing the impact of the CO2 in the concrete contained in structures.</td>
<td></td>
<td>started in 2018</td>
</tr>
<tr>
<td>Partnership</td>
<td>Location</td>
<td>Project/Initiative</td>
<td>Details</td>
<td>Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
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<td>--------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicat and Carbon8</td>
<td>Montalieu - Vercieu</td>
<td>CO2ntainer System</td>
<td>Installation of a CO2ntainer system in a cement plant to help boost growth in the use of alternate fuels in the cement-making process and uses captured CO2 to carbonate cement-plant dust and produce quality aggregate</td>
<td>operating since 2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicat, AlgoSource and Total</td>
<td>Montalieu</td>
<td>Cimentalgue</td>
<td>Testing the potential for using captured CO2 to increase microalgae harvests, also involving recovering waste heat from the kiln stack.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicat and EDF (Hynamics)</td>
<td>Montalieu</td>
<td>HyNoVi</td>
<td>Installation of a 330 MW electrolyzer to capture CO2 from the kiln exhaust stack in the Vicat plant, and harnessing oxygen for oxycombustion.</td>
<td>Capture 40% of CO2 emitted by 2025</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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