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European Commission

SCIENCE FOR POLICY BRIEF

Learning from publicly funded research on cement decarbonisation options

HIGHLIGHTS

→ 334 nationally funded research projects on cement decarbonisation, added to EU-funded projects, were analysed from 21 of a total of 31 European countries examined.

→ 17 countries report national funding for 307 projects of EUR 209 million. Project funding was higher on average under H2020, with 71 projects receiving EUR 416 million. The smaller, more numerous national projects are better suited to lower technology readiness levels.

→ H2020 provides three times more funding on carbon capture research than national authorities (EUR 180 million compared to EUR 57 million). Of the ten countries investing in CCUS for the cement industry, nine have access to the sea.

→ Alternative cement chemistries are investigated across all European countries, with close to 250 projects investigating specific aspects of this broad theme.

This factsheet highlights the potential to coordinate research funding across Europe in the decarbonisation of the cement industry. In light of the climate emergency and the 2050 objectives set by the Paris Agreement, decarbonisation efforts are increasing globally. This is especially true for the CO_2-intensive cement industry, which plays a key role in our infrastructures and our economy. Research funding is critical for the development of sustainable solutions. Due to the regional nature of its operations, the cement industry benefits from funding at various geographical levels. Based on this analysis of the various solutions supported by EU and national funding, strategic decisions can be made to reinforce the industry's research ecosystem.

POLICY CONTEXT

The cement industry is of relevance to society at large and connected to several policy areas. Cement is a material of choice for the construction industry. Much of our infrastructure is built with it, and it makes a valuable contribution to the European economy and to employment right along its value chain.

With 2050 approaching, societal efforts on decarbonisation are increasing globally. This is especially the case for research in the cement industry, responsible for approximately 8% of global greenhouse gas emissions. Research is also an avenue for addressing other issues faced by energy-intensive industries, such as environmental protection (pollution control), economic affairs (competitiveness) and linked social aspects (health and employment).

The localised nature of the cement industry provides multiple possible solutions and decarbonisation options. With close to 200 integrated cement plants across the EU, most of which are owned by multinationals, the industry appears to be consolidated. Yet it operates at a regional scale, due to the relatively high cost of

transporting of commodities compared to the price of products. This regional dimension, in terms of raw material and fuel supply, plays a role in the decarbonisation options of plants and their long-term prospects, motivating research into local solutions.

CLASSIFICATION OF DECARBONISATION OPTIONS

A structured mapping of the options is instrumental to achieving decarbonisation objectives. The cement industry is developing a wealth of techniques and technologies for its decarbonisation. These options are distributed across research projects, reports and literature, hindering a clear understanding of the overall picture.

Europe funds numerous research projects on cement decarbonisation, at national level (collected for the purpose of this factsheet) and at EU level (as previously identified [1]). Taking note of the content of these enables the creation of an extensive list of decarbonisation options.

Decarbonisation options can be broadly classified into themes depending on the type of emissions addressed. The production of grey Portland clinker is responsible for the vast majority of emissions (due to the emission-intensity of this product and the volumes produced). These emissions can be broken down according to their origins: the decomposition of calcium carbonates, fuel combustion and electricity consumption.

Box 1: Approach

This factsheet strives to create a clearer picture of the state of play in cement decarbonisation. Research is examined at country level, thereby covering alternative, additional funding streams and viewpoints. Alongside this broad approach, each project is analysed in depth, according to the decarbonisation options investigated. Their integration provides a detailed classification of cement decarbonisation options which will enable more strategic focus in terms of funding coordination.

The themes addressed have varying decarbonisation potential. Relying on carbon-free alternative materials, in place of limestone, addresses 60% of clinker emissions known as process emissions. Relying on alternative fuels, especially decarbonised electricity or carbon-neutral biomass, addresses emissions from fuels. About 30% of clinker emissions comes from fuel combustion for thermal processes and 10% from electricity consumption. Efficiency addresses marginal gains linked to fuel and electricity consumption, while Carbon Capture, Utilisation and Storage (CCUS) has the potential to address all (local) clinker emissions at once.

Classification helps to make sense of the complexity. While the cement industry may appear straightforward, with one main production process and a limited number of products, the options for decarbonisation can still be overwhelming. Figure 1 reduces this complexity through classification. From coarse to aggregated, the classification covers three levels:

a) *detailed decarbonisation options* including specific technologies (e.g. Organic Rankine Cycles or Membrane based CO_2 capture) and techniques (e.g. electrification);

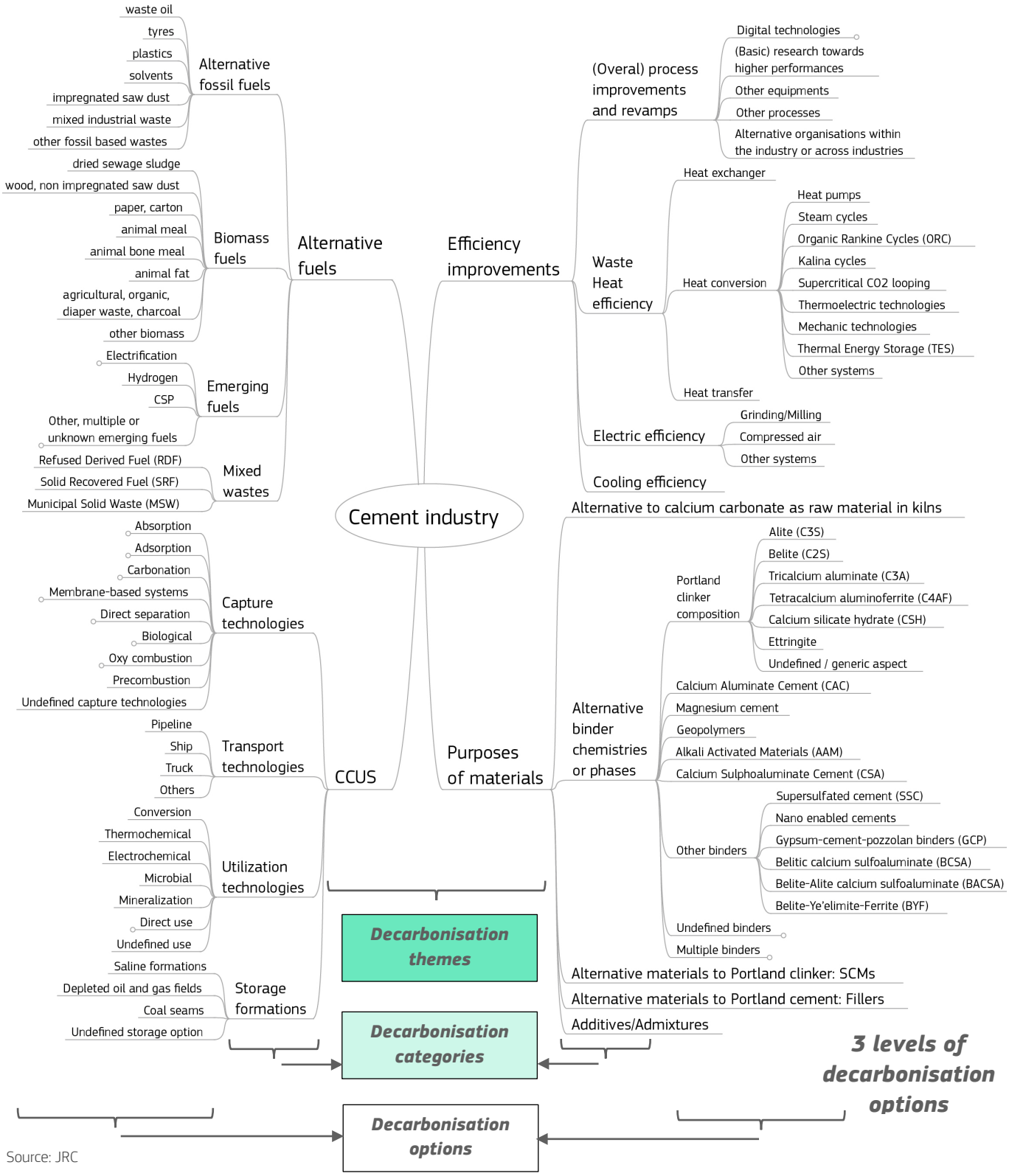
b) *decarbonisation categories* (e.g. supplementary cementitious materials, whose increased use reduces the need for CO_2-intensive clinker);

c) four *broad decarbonisation themes* (efficiency, fuels, materials and CCUS).

Box 2: Methodology

This study focuses on the 27 EU Member States plus Iceland, Norway, Switzerland and the United Kingdom. Projects funded since 2014 are retrieved from [2] to [33]. Relevant projects are filtered by the use of keywords such as ‘clinker’, ‘cement’ and ‘binder’. They are then validated by reading their description, allocating them to various detailed decarbonisation options and enhancing the list in the process (Figure 1). The number of detailed options addressed by each project is recorded (Figure 2) and taken into account when reporting funding according to these options (Figures 3 and 4).

Figure 1 – Proposed classification of cement decarbonisation options



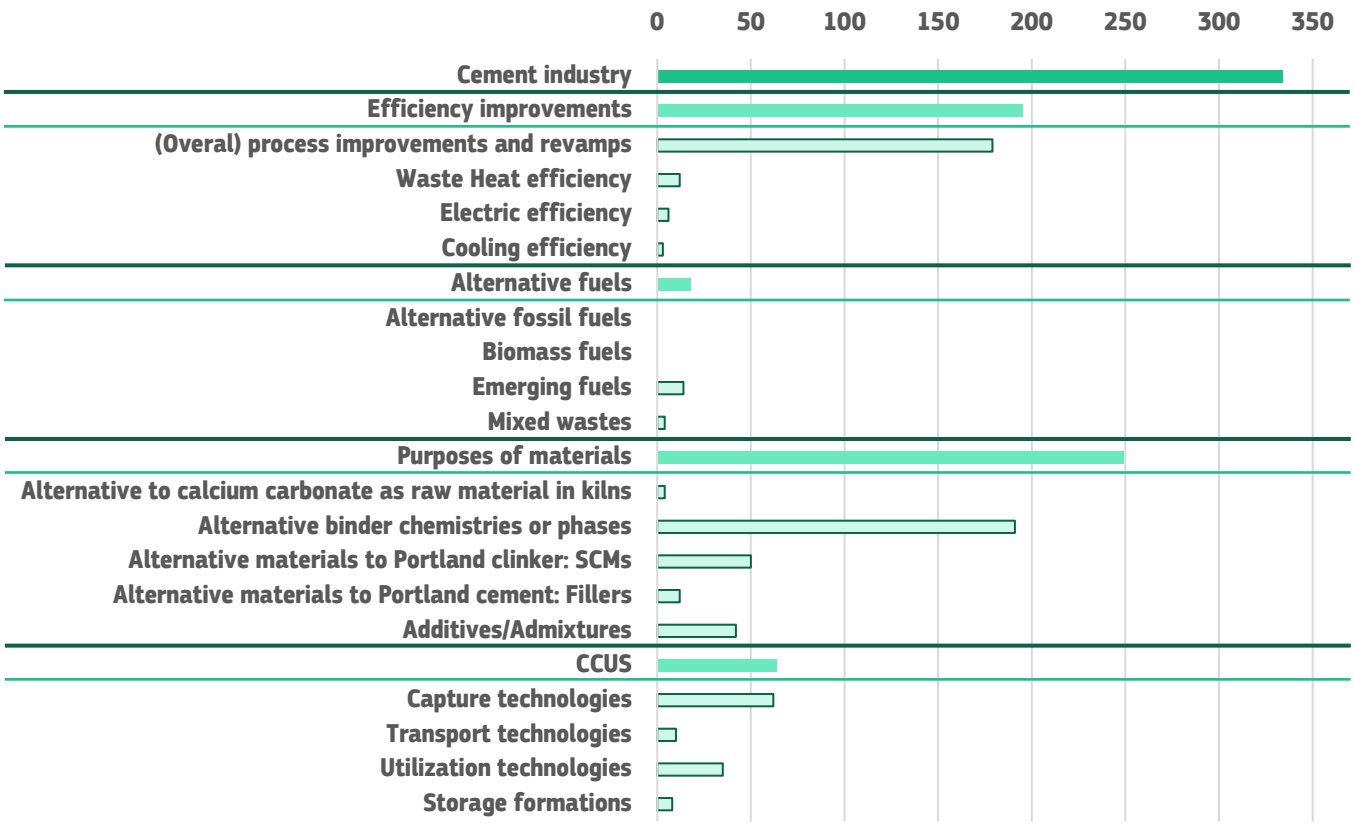
Source: JRC

RESEARCH DIRECTIONS ACROSS EUROPE

Not all research directions which have been identified receive a similar level of support.

Sorting the projects thematically offers insights into the relative importance of each decarbonisation option. Across European countries, binder chemistries and process improvements are each investigated by more than half of the projects, while merely 10% look into alternative fuels.

Figure 2 – Number of nationally funded research projects along decarbonisation themes and categories ([1]).



Source: JRC.

Figure 2 shows the number of projects addressing categories of decarbonisation options. This chart provides a breakdown of research efforts and priorities across European countries, grouped into four broad themes of efficiency, fuels, materials and CCUS. Each of these themes is further broken down into four or five categories.

Over 70% of identified projects address (raw) materials, with particular attention to alternative binder chemistries. Significant research effort is focussed on this core issue, which touches on the largest source of CO_2 emissions from the cement industry, namely limestone calcination. Other chemistries may also (indirectly) address the remaining themes, e.g. with alternative production processes, lower energy intensity or requirements and (re)carbonation.

The cement industry is performing research along the whole CCUS chain. Most projects relate to carbon capture, as this step directly impacts the cement production process. However, CO_2 capture makes sense only in combination with the remaining steps of the CCUS chain (i.e. CO_2 use or transport and storage). As the quality of the CO_2 influences its use, transport and storage options, these steps of the CCUS chain are also being investigated by research projects in the cement industry.

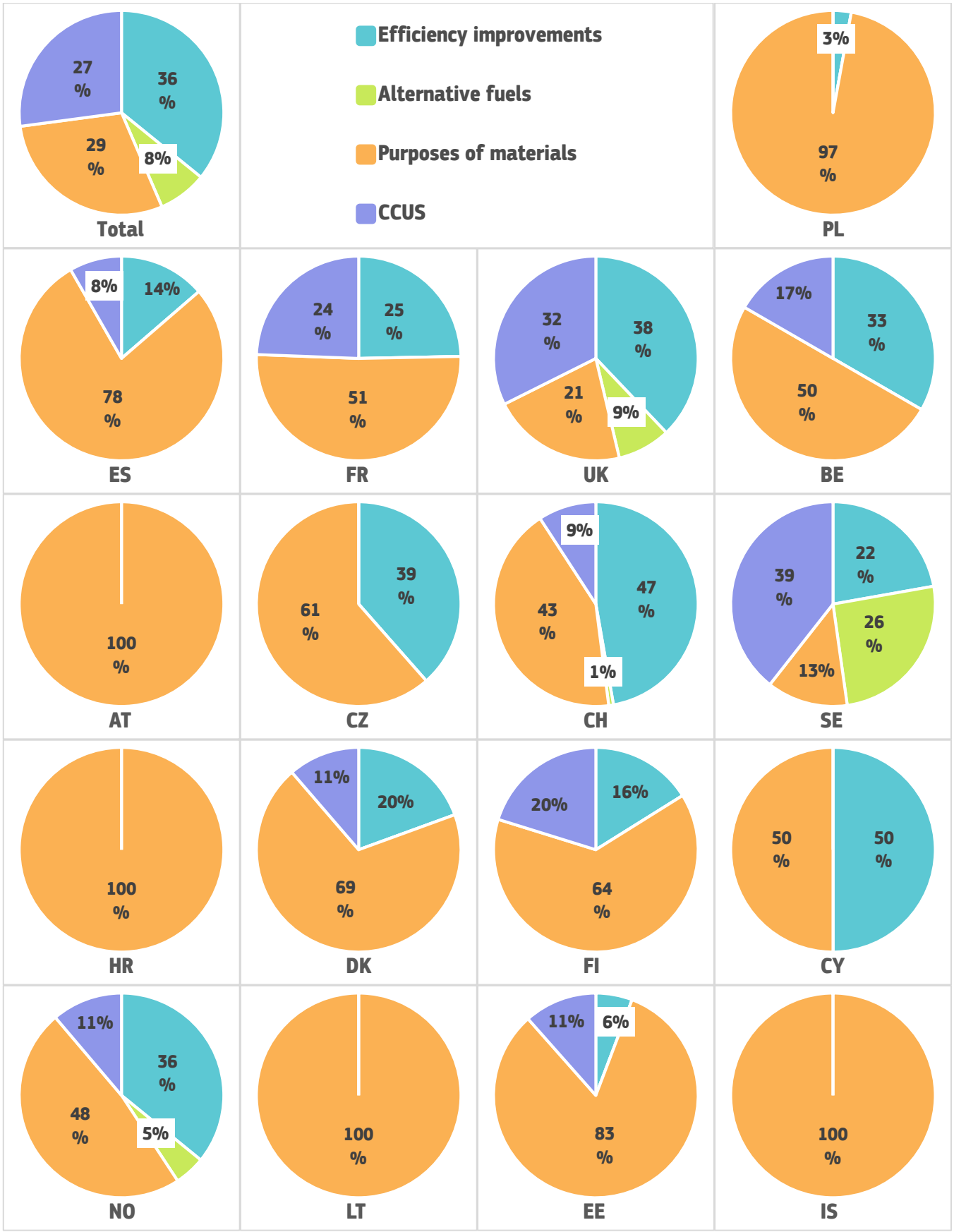
FOCUS ON NATIONAL SPENDING

Of the 27 EU Member States and their four European neighbours of Iceland, Norway, Switzerland and the United Kingdom, projects are identified in 21 countries. Some countries do not disclose funded projects (irrespective of the focus), while others provide extensive search tools and/or project details. Of the 21 countries whose projects are identified in this analysis, 17 (displayed in Figure 3) report the level of funding granted.

The analysis reveals geographical discrepancies across research themes. Efficiency is the most funded theme investigated in twelve countries, while research on materials (and chemistry) takes place in all of the countries considered. Spending on CCUS and alternative fuels is more limited, with funding from ten and three countries, respectively. Countries investing in CCUS are (primarily) coastal, and those investing in alternative fuels are located in northern Europe.

([1]) Projects contributing to multiple detailed decarbonisation options are accounted for in each theme or category of relevance.

Figure 3 – Share of funding allocated to decarbonisation themes for countries reporting publicly funded research ([2]).



Source: JRC

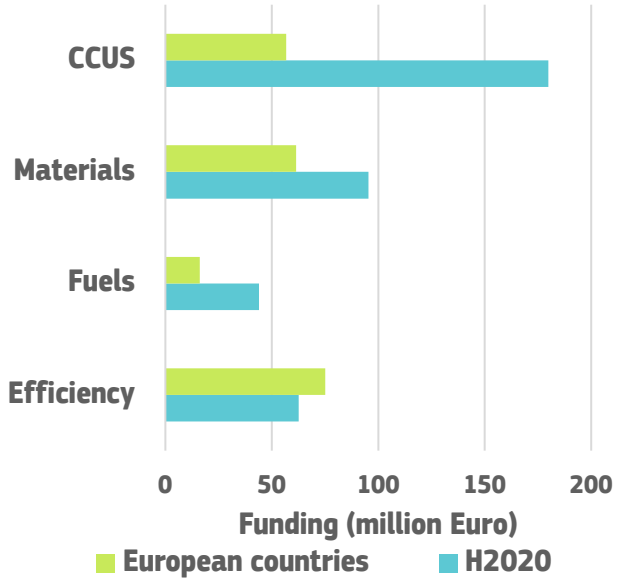
([2]) DE; LV; NL & SI do not disclose grant amounts. No relevant projects are identified for BG; EL; HU; IE; IT; LU; MT; PT; RO & SK. Countries are ranked by decreasing cement production volumes in 2021.

COMPLEMENTARITY WITH EU ACTIVITIES

Research in the cement industry receives financial support within and across European countries. EU framework programmes enable the funding of large projects closer to commercialisation. The national approach offers broader coverage, targeting smaller projects and possibly nascent solutions. Beyond research funding, **the EU also offers the coordination of efforts through the joint implementation of activities under the SET Plan.**

Funding at country level and through EU research programmes are of a similar order of magnitude. We have compared national funding with the H2020 projects identified in [1]. The projects funded at country level receive EUR 209 million. H2020 projects have a total budget of EUR 416 million (with EUR 333 million of EU funding). This difference can at least partly be explained by data availability, as funding is not reported for 52 of the national projects.

Figure 4 – Spending on cement decarbonisation themes across European countries and through H2020 ([3]).



Source: JRC, partially based on [1]

Project sizes differ across the two funding streams. This factsheet considers 334 nationally funded projects. Of these, only four receive over EUR 10 million of funding. At the other end of the scale, 68 projects receive less than EUR 0.1 million. In the case of the 71 H2020 projects identified in [1], 13 receive over EUR 10 million of funding and one receives less than EUR 0.1 million. Large H2020 projects appear to be the demonstrators referred to in [34].

H2020 outperforms national funding in three of the four cement decarbonisation themes. H2020 spending exceeds national funding by over 50% on materials and nearly triple the amount for alternative fuels and CCUS. Efficiency is the only exception.

In efficiency, H2020 funding is 20% lower than that of European countries taken together (Figure 4). This might be explained by the detailed classification used in this analysis (see Figure 1), which extends the scope of efficiency to cover digital approaches and process improvements. It might also be explained by the revision of the methodology, as national projects can be allocated to several themes, whereas H2020 ones are not. However, the level of spending remains similar between the EU and national funding schemes, with the lowest variation of the four themes.

Research in alternative fuels consistently receives the least funding at H2020 and national level. Cement is an energy-intensive industry, consuming large amounts of fuel for thermal processes. Fuel accounts for a large share of costs and yields around 40% of emissions. Competitiveness may prove to be a stronger driver for fuel substitution than decarbonisation ambitions.

Research funding on CCUS is far more pan-European in nature. Meaningful CO_2 capture requires a whole processing chain to transport and use or store emissions. This chain is expensive in terms of research, but also in terms of the infrastructure required for largescale CCUS implementation. Lastly, the international dimension of CO_2 transport and storage, especially offshore, calls for a concerted, pan-European approach [35].

European countries strive to collaborate and jointly progress on energy efficiency in

([3]) H2020 data is retrieved from [34] without re-processing data according to the methodology and classification presented in this factsheet and applicable to national funding: in [34] H2020 projects were allocated to only one theme. Besides the four themes, an additional 'Others' theme kept track of projects with ambiguous research direction. This 'Others' theme explains the discrepancy between the total budget quoted in the text (EUR 416 million) and the spending on themes displayed on figure 4 (EUR 382 million).

industry. Established in 2017, the Strategic Energy Technology Plan (SET Plan) Action 6 is dedicated to making EU industry less energy-, resource- and emissions-intensive and more competitive. Eighteen countries contribute to the Implementation Working Group, which aims to advance the realisation of the Implementation Plan [36]. The plan was revised in 2021 on the basis of progress made on the joint R&I activities.

The joint SET Plan activities align with the decarbonisation themes picked out in this analysis. The four cement industry activities in Action 6 address the themes of alternative fuels and materials (resource efficiency through alternative fuel use and alternative materials for clinker replacement); of efficiency (energy efficiency through kiln conversion and waste heat recovery) and of CCUS (capturing CO_2 from cement kilns and enhancing recarbonation of recycled concrete).

Lastly, this analysis of commonalities could be deepened if Member States were to detail activities and funding in these themes in their National Energy and Climate Plans. It is hoped that this factsheet will serve as a stepping stone in this direction.

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CONTACT INFORMATION

Alain.Marmier@ec.europa.eu