Department for Business, Energy & Industrial Strategy

mpa essential materials sustainable solutions

Cement Sector

Joint Industry - Government

Industrial Decarbonisation and Energy Efficiency Roadmap Action Plan

October 2017

JOINT ACTIONS TO DELIVER THE 2050 DECARBONISATION ROADMAPS

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Foreword from the Mnister of State

With industry representing nearly a quarter of UK emissions, helping industrial sectors decarbonise and improve their energy efficiency is a crucial part of our Clean Growth Strategy. It will also be essential for achieving the Industrial Strategy's aims of reducing business energy costs, improving industrial productivity and competitiveness, and driving clean economic growth.

Globally, investment in clean technologies is rising while costs fall. Against this backdrop, few countries have been more successful than the UK in growing their economy while reducing emissions – cutting UK emissions by over 40 per cent[1] while growing the gross domestic product of the overall UK economy by 67 per cent[2]. In parallel the UK has been improving energy security, creating jobs and realising export opportunities from the new industries and companies that have been created.

The Industrial Decarbonisation and Energy Efficiency Roadmaps project is a key collaboration between Government and industry to help industry make the low carbon transition while also maintaining its competitiveness. The publication of this action plan is an important milestone for the project, as it identifies commitments from all parties to enable the cement sector to decarbonise and improve its energy efficiency. These commitments build on the potential identified in Phase 1 of the Industrial Roadmaps project, which provided an evidence base of the carbon savings industry could expect to make in different decarbonisation scenarios.

The actions in this plan would not have been possible without such strong and constructive input from the cement sector so I would like to extend a huge thank you to them for helping us get this far. They are voluntary but provide an important framework for future decarbonisation and energy efficiency improvements, all the way up to 2050. They cover specific technological solutions such as increasing production of lower carbon clinker and novel low carbon cements and fuel switching, and also wider themes such as innovation, skills development and investment which are all key pillars of the Industrial Strategy.

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[1] Provisional 2016 emissions: BEIS provisional UK emissions statistics 1990-2016: https://www.gov.uk/government/statistics/provisional-uk-greenhouse-gas-emissions-national-statistics-2016

[2] Office for National Statistics, 2017, ABMI GDP series,1990-2016: https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/abmi/pgdp

The identification and publication of these actions is not the end of the Industrial Roadmaps project. All parties are committed to working together to implement this action plan, while also meeting future decarbonisation challenges and opportunities as the landscape evolves. So its publication is in many ways a starting point to build on for further collaborative working, as well as a key project milestone in its own right. By building on the collaborative way of working that has been so effective so far, we will ensure this Action Plan makes a significant contribution to the Industrial Strategy's aim of delivering clean economic growth, and that it maximises the economic benefits from the UK's transition to a low carbon economy.

Claire Perry
Minister of State for Climate Change and Industry

Industry Foreword

Climate change is the principal environmental issue for the cement industry for two important reasons; firstly because cement manufacture is a CO_2 intensive production process and secondly, in its functional form of concrete, the product can help to decarbonise society, especially by reducing energy use in buildings.

From 1990 to 2015, the carbon intensity of cement reduced by 27 per cent[3] and absolute emissions have reduced by 52 per cent[4]. This has been achieved as described below.

Traditional cement manufacture is a fuel intensive, electro-intensive and CO_2 intensive process. Considerable action has already been taken to replace fossil fuels with alternatives. In 2015 the UK cement industry replaced 42% of its fuel demand with waste derived alternatives. This example of the circular economy in action provides a valuable outlet for low value materials from other industrial, commercial and domestic sectors and reduces the need for additional landfill and incineration capacity.

However, the majority of CO_2 emissions (around 70% in the UK)[5] from the manufacture of cement arise from raw materials (process emissions).To address these emissions, the UK cement and concrete industry has progressively reduced the amount of 'clinker' (the CO_2 intensive active ingredient in cement) in the concrete formulations used in construction. Cement produced in the UK in 2015 contained an average of 29%[6] clinker substitute materials, comparable with the best in Europe and cement consumption per capita in the UK is 173 kg, which is considerably lower than the EU28 average of 307 kg

Taking action on these two issues, as well as making further efficiency improvements and investing in state of the art plant over recent decades, has facilitated UK cement manufacturing to become significantly more resource, energy and carbon efficient. The reduction in carbon intensity

[3] Data collected from all UK cement plants by MPA.
[4] MPA Cement, "Greenhouse Gas Reduction Strategy", 2013, http://cement.mineralproducts.org/current_issues/climate_change/greenhouse_gas_reduction_strategy.php
[5] MPA Cement "Sustainable Development Report 2016", 2017
[6] MPA The Concrete Centre on behalf of The Sustainable Concrete Forum, "Concrete Industry Sustainability Performance Report, 9th Report: 2015 performance data", 2017.

demonstrates that the cement sector has been working to reduce its greenhouse gas emissions, making further decarbonisation now more challenging. However, part of the absolute reduction is the result of plant closures and a reduction in capacity. It is important to avoid further closures and for Government and industry to collaborate to ensure that decarbonisation is achieved cost-effectively and not through deindustrialisation.

The Government 2050 Energy Efficiency and Decarbonisation Roadmap for the cement sector ('Cement 2050 Roadmap'), published in March 2015, clearly identified that there are a small number of options offering 'step change' carbon abatement in the cement sector. Over 90% of the reductions identified in the current trends Max Tech with CCS/U decarbonisation scenario is reliant upon three principle techniques:

1. Carbon capture (with storage or utilisation)
2. Increased biomass use instead of fossil fuels
3. Lower clinker content cements

This conclusion echoes the output of the industry's own assessment in the MPA 2013 Decarbonisation Roadmap[7]. Furthermore, the importance of carbon capture is well recognised for the delivery of the UK carbon budget. The Committee on Climate Change conclude that few abatement options exist for manufacturing sectors such as cement, and that Industrial CCS/U has the most significant abatement potential. Notably, if CCS/U is not delivered in a timely manner the pressure on other technologies such as biomass will increase in importance. It is therefore extremely important that the Government comes forward with a clear, deliverable, set of policies to support CCS/U in sectors such as cement.

To achieve the deep levels of decarbonisation identified in the Roadmap many hundreds of millions of investment would be needed and unfettered this would create a competitive disadvantage for UK manufacturers, particularly in the short term. As such, the UK cement industry considers that many of the actions in this action plan are contingent upon 10 principle contextual characteristics:

[7] Mineral Products Association, 2013, "UK cement industry 2050 Greenhouse Gas Strategy", http://cement.mineralproducts.org/current_issues/climate_change/greenhouse_gas_reduction_strategy.php

1. Long-term regulatory stability and visibility where any targets/requirements are realistic and both technically and financially achievable;
2. Full carbon leakage mitigation for installations in the EU ETS or future UK equivalent;
3. Secure energy supplies at internationally competitive prices;
4. Support schemes that are long-term with eligibility for all installations especially to encourage investment in proven energy/carbon-efficient technologies which are currently out of financial reach;
5. Where the policy focus is not just on lower carbon production but the performance of products throughout their lifetime and after use;
6. By accounting for embedded carbon in imported goods when setting polices to ensure that domestic carbon budgets are not partially met by increasing imports;
7. Implementing the concept of a circular economy to maximise resource efficiency and industrial symbiosis;
8. Installing a targeted innovation and deployment programme for new/novel technologies with specific eligibility for the decarbonisation of cement manufacture.
9. A support framework with, financial commitment as necessary, to assist in the deployment of the three principle decarbonisation technologies relevant to cement manufacture.
10. Continued support for the roadmap action plan implementation beyond the current Parliament.

Against this backdrop, the Mineral Products Association (MPA) welcomes the collaborative approach between the cement sector and the UK Government set out in this Action Plan. This Action Plan sets out an aspirational framework for Government and industry to work together. A balanced contribution from Government, industry and other influential stakeholders will assist in overcoming the key challenges for an economically beneficial, environmentally sustainable and socially valued cement manufacturing sector for the long-term benefit of the UK.

Dr Richard Leese

Director - Industrial Policy, Energy and Climate Change
Mineral Products Association

Undersigned support the broad aims of this Action Plan and agree to support the ongoing collaborative work between the UK government, UK cement manufacturers, the Mineral Product Association and other key stakeholders, to reduce carbon emissions and contribute to overall decarbonisation of the UK by 2050, whilst strengthening the international competitiveness of UK cement manufacturing. This collaboration is outlined in the 'UK Cement Manufacturing Decarbonisation and Energy Efficiency Action Plan'

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The parties named in this action plan support the actions attributed to them, but have not made a legally binding commitment to fulfil those actions.

Introduction and Policy Overview

This document describes priority agreed actions to be implemented by a range of stakeholders in the UK cement sector. The actions, which are intended to enable and deliver decarbonisation and energy efficiency in the UK while maintaining sector competitiveness, have been identified by stakeholders from industry, government and other parties, including actors within the value chain, supply chain, institutions and academics. They focus on overcoming barriers and delivering the decarbonisation pathways identified in the previously published 2050 Industrial Roadmaps reports[8].

The parties to the agreement expect progress with addressing the identified issues to be monitored, and the plan itself to be updated over time to reflect new developments and other changes.

This Action Plan is voluntary and jointly-owned between government and industry. Government Departments (led by BEIS) and the cement sector (led by MPA) will work together to oversee delivery of the Action Plan and future work, regularly updating on progress.

To achieve this, BEIS and the sector Trade Associations will set up a Roadmap Strategy Group to provide an ongoing forum to discuss and review the delivery of the tasks in this action plan.

The group will focus on:

- A review of Action Plan delivery, progress and reporting.
- A strategic overview of cross sectoral actions.
- Overseeing the development of future actions that can secure the objectives of the plan.

[8] https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

Policy Framework

As set out in the Industrial Strategy Green Paper, recent UK energy policy has developed through the framework of a 'trilemma' – the need to simultaneously find policies that contribute to meeting climate change targets, guarantee security of energy supply and minimise energy costs. One of the three major challenges for energy policy (that the industrial strategy will address) is to ensure that the transition to low-carbon economy – and the securing of our energy supplies – must be done in a way to minimise the cost to business and domestic consumers.

In 2015 the world committed to the historic Paris Agreement which saw 195 countries commit to take action to reduce emissions. This Agreement included the goal of keeping the global mean temperature rise to well below two degrees, whilst pursuing efforts to limit temperatures rises to less than 1.5 degrees. Additionally, the Agreement enshrines a goal of net zero greenhouse gas emissions in the second half of this century. The UK is already playing its part in delivering the Paris Agreement through its domestic climate framework. This framework includes the UK Climate Change Act which sets a target to reduce greenhouse gas emissions by at least 80% by 2050, against 1990 levels. To do so, the UK needs to move to a more energy efficient, low-carbon economy whilst also ensuring a thriving and internationally competitive industrial sector.

As part of the UK's commitment to the Act the government is required to publish a plan which sets out how the UK will decarbonise its economy through the 2020s. For industrial sectors, this plan draws on the collaborative work of the 2050 Industrial Roadmaps project and these Action Plans. The UK has already reduced its territorial emissions by 42%[9][1] since 1990 while growing the overall economy by over 67%[10]. Industrial carbon emissions including those from energy-intensive industries (EIIs) have halved since 1990, which has mainly been due to efficiency gains, fuel switching, a change to industrial structure of the UK and re-location of production overseas.

However, more will need to be done, and it is a shared challenge for Government and industry to realise not only these emissions savings but also the industrial opportunities of the transition to a clean economy. These emissions savings will be predominately achieved by the eight industrial sectors that currently emit approximately two thirds of industrial carbon emissions: cement, ceramics, chemicals, food & drink, glass, iron & steel, oil

[9] As in footnote 1.
[10] As in footnote 2.

refining, and pulp & paper. These sectors make a significant contribution to our economy, employing around 2% of the UK's workforce - often in regions of high relative deprivation - and making up approximately 18% of our exports[11]. The mineral products industry contributes £6.4 billion gross value added to the economy with an annual turnover of £20 billion .

There is substantial scope for collaboration between industry, government and others to take steps in the short term that could enable industry sectors to make deeper emissions reductions over the longer term, while staying competitive. The first phase of the Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050 showed that deep decarbonisation of EIIs is achievable. However, there are significant barriers, including cost; economic, business and policy uncertainty; knowledge and skills gaps; and access to finance. These issues are explored further through this paper[12].

Following publication of the Cement Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050, Government and the Mineral Products Association have now agreed this Action Plan, setting out voluntary commitments that each party will undertake to enable the cement sector to make deeper emissions reductions over the longer-term while staying competitive. This involves the following actions:

- Facilitating the deployment of carbon capture and storage/utilisation
- Increasing the use of waste-derived and/or sustainably sourced biomass fuels
- Increasing the production of lower clinker and novel low carbon cements
- Increasing the deployment of state-of-the-art energy efficient technologies
- Increasing waste heat recovery
- Highlighting the rtole that the UK cement sector plays to enable carbon reduction across the value chain and in the built environment
- Minimising business energy costs to support investment in the UK cement sector

[11] Statistics derived from ONS data on exports and workforce
[12] https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

1. Actions

1.1 Action 1: To facilitate the deployment of carbon capture and storage/ utilisation (CCS/U) in the UK cement sector

- CCS has the potential to reduce emissions by over 2.5 million tCO_2 by 2050 under the Current Trends, Max Tech with CCS/U scenario.
- CCS is the most important technology to decarbonise cement manufacture, as 70% of CO_2 emissions in the sector come from the chemical process of calcining calcium carbonate[13] (process emissions) rather than energy use. There are currently no other technologies that offer the same level of decarbonisation potential in the cement industry.
- Carbon capture and utilisation (CCU) is an important option and offers economic opportunities, but it is unlikely, on its own, to be sufficient, as not all CO_2 usage technologies lead to permanent CO_2 reductions. Importantly though, deploying CCU can reduce the costs of capture technology and can be tested at existing UK industrial sites. CCU can also lower the carbon footprint of products, and provides opportunities for industrial symbiosis with commensurate economic benefits.
- A significant amount of relevant activity is already underway in the cement sector (see case study).
- This action includes undertaking studies on the potential of various technologies and the potential of industrial cluster for deployment of CCS/U, both of which may provide useful input in the future deployment of CCS/U in the cement sector.
- The objective of the action is to help develop an understanding of what is required in order to deploy CCS/U and to support and create the conditions for deployment. It will involve collaboration between central Government, industry and local authorities.
- As well as the specific tasks set out in this action, HMG has set out details of its new approach to CCUS in the Clean Growth Strategy, which was published at the same time as this document. This approach is relevant to industrial sectors, and Government will work with the cement sector as part of the ongoing roadmaps process, to help them realise the opportunities that it presents for them.

[13] The basic chemistry of the cement manufacturing process begins with the decomposition of calcium carbonate ($CaCO_3$) at about 900°C to calcium oxide (CaO, lime) and liberated gaseous carbon dioxide (CO_2); this process is known as calcination.

Action 1 Tasks

Task 1A (cross-cutting): Assess the potential of CO_2 utilisation in the UK through a study to identify the most promising applications of CCU and how CCU commercialisation can be facilitated.
Task Owner: BEIS
Timing: 2018

Task 1B (cross-cutting): Build understanding of the potential for deploying CCS/U at industrial sites by commissioning reports on the level of development at industrial clusters, including opportunities for making further progress, and on the options for deploying CCS at industrial sites that are isolated from carbon transport and storage infrastructure..
Task Owner: BEIS
Timing: 2018

Task 1C (cross-cutting): Undertake activity to raise public awareness of CCS/U in communities close to potential deployment sites.This should be done as part of BAU engagement activity. Detailed and bespoke public engagement on CCS/U would ultimately be taken forward as part of any specific CCS/U project.
Task Owner: MPA, in collaboration, members and local authorities.
Timing: When required (2025+)

1.2 Action 2: To increase the use of waste-derived and/or sustainably-sourced biomass fuels in UK cement manufacture

- The 2050 Decarbonisation and Energy Efficiency Roadmap for the cement sector, under the Current Trends, Max Tech with CCS/U scenario, indicated that fuel switching to waste derived biomass / sustainably-sourced biomass fuels has the potential to deliver 27.7% of the 2050 reduction in emissions. This equates to around 1.1 million tonnes of CO_2 by 2050.
- The cement sector has already taken early action in the use of waste derived biomass/ sustainably-sourced biomass fuels which currently contribute 20% of the thermal input.
- This action aims to support the continued efforts of the cement industry to increase the use of waste derived biomass, mixed-waste streams containing biomass, and sustainably-sourced biomass fuel for cement production, reducing the emissions produced by fossil fuel combustion during this process. As fuel-related CO_2 emissions are currently 30% of the total emissions from the cement sector, further CO_2 reduction can be achieved but this is subject to the availability of suitable biomass fuels at economically viable prices, and the ability to overcome technical complexities associated with using a wide range of different fuels. Technical barriers and the limited availability of 100% biomass fuels makes the achievement of 100% biomass fuel input extremely challenging.
- Consideration is needed of the best use of limited supplies of biomass across the economy, followed by ensuring that the policy environment and initiatives are in place to achieve this.
- The objectives of the action are to facilitate the optimum use of existing biomass fuels within the cement sector taking into account sustainability factors, and to enable new sources of low-grade biomass to be used as fuel.
- The action includes short term tasks focussed on identifying the availability and use of waste biomass fuels which could be used economically by the cement sector and establishing policy regimes to encourage their use by the cement sector. The action also includes a series of longer term actions focussed on the demonstration and implementation of technology that improves waste biomass suitability for use (e.g. creating a fuel with less moisture content or removing unwanted fractions), in order to increase the types and volumes of biomass fuel that may be utilised in the cement sector.

Action 2 tasks

Task 2A (cross-cutting): Industry and Government to set up a cross-sector group to develop a collective view of the best uses of bioenergy across industry. This group will use analytical tools to identify the likely future supply and demand of different bioresources (including waste biomass resources), their costs, and their environmental sustainability– eg: BEIS's Bioenergy Resource Model and UK land use assessments. The group will be informed by evidence of the role bioenergy could play in the UK's future decarbonisation objectives, and by the emerging findings from the Government's Bioeconomy Strategy regarding the role of bioenergy in the UK's wider bioeconomy, as well as consideration of the waste hierachy
Task Owner: BEIS with industry input
Timing: 2017-2019

Task 2B: Examine the maturity of technology for the use of waste-derived fuels in Europe, identifying opportunities for cross-fertilisation from elsewhere in Europe to the UK.
Task Owner: MPA, supported by CEMBUREAU
Timings: 2018

Task 2C: Follow up its call for evidence on fuelled technologies and geothermal in the Contracts for Difference (CFD) scheme. This will facilitate assessment of whether any further policy proposals are needed. Furthermore, in line with the forthcoming bioeconomy strategy, assess and develop policy proposals and measures to optimise waste derived fuel /biomass use, ensuring best value for money is achieved.
Task Owner: BEIS
Timings: 2017-2018

Task 2D: Depending on outcomes of the cross-sector group's consideration of the best uses of bioenergy across industry : carry out a study on improving waste biomass quality for fuel use, and identification of new waste biomass source streams for cement manufacture.
Task Owner: BEIS, with technical input from MPA / cement companies, waste management companies and research organisations
Timings: 2018 – 2019

Task 2E: Government should communicate the outputs from analytical work assessing the role biomass could play in the UK's future decarbonisation and economy. It is expected that this will cover a range of policy areas including the Bio-economy Strategy, use of bioenergy in industry and government's approach to long-term carbon budgets. This will provide a clearer idea to industry of the current and future policy landscape for bioenergy
Task Owner: BEIS
Timing: 2017-2018

Task 2F (cross-cutting): The cross-sector group to develop a collective view on the best uses of bioenergy for each sector, including which technologies, processes and stages of the supply chain are of interest. This 'best use' will need to consider sustainability, economic value and technological feasibility.
Task Owner: BEIS
Timing: 2017 - 2019

Task 2G : Review the benefit of decarbonisation of fuel switching to biomass in direct firing operations.
Task Owner: BEIS, with input from the MPA
Timing: 2018

1.3 Action 3: To increase production of lower clinker and novel low carbon cements in UK cement manufacture

- According to the 2050 Roadmap for the sector, the use of cementitious materials to substitute clinker in cement manufacture could achieve between 150,000 – 180,000 tCO_2 reduction by 2050, while the deployment of non-Portland novel cements is estimated to have the potential to save around 150,000 tCO_2 by 2050.
- In the UK, whilst factory made cements do replace certain amounts of clinker with cementitious materials, this is supplemented by additions at the concrete plant (see case study). When overall cementitious replacement is measured at the concrete level, the UK compares favourably with the rest of EU at 29% cementitious additions in 2015[14]. Packed cement products all contain clinker substitutes in the UK.
- Clinker substitution involves reducing the amount of clinker per unit of cement by substituting the clinker with other cementitious materials, such as pulverised fuel ash (a waste from coal fired power stations) or ground granulated blast furnace slag (a by-product from iron and steel manufacture), pozzolanic materials, and materials such as limestone..
- Novel or 'new' cement types are generally non-Portland, based on non-traditional processes or raw materials. They tend to embody less energy and emit less CO_2 during manufacture than standard Portland cement.
- The increased use of clinker substitute materials and the development of novel cements have been combined into a single action to reflect the interdependency of these decarbonisation technologies, which both utilise the same alternative materials, for which there are only finite resources available.
- The action includes a series of tasks that seek to:

    1. increase the availability and use of established clinker substitutes;
    2. identify and facilitate the use of alternative substitute materials;
    3. develop and demonstrate the whole-life performance of novel, low carbon cements;
    4. develop technical specifications for selected novel cements such that they are able to be selected by the construction sector as low

[14] "Concrete industry sustainability performance report: 9th report: 2015 performance data", MPA The Concrete Centre, on behalf of the Sustainable Concrete Forum, 2017.

carbon alternatives to Portland cement without compromising performance or safety.

- Implementation of this action aims to deliver increased levels of clinker substitution in cement, and hence a reduction in clinker requirements, and commercially available, novel, low carbon cements that may be utilised in the UK construction sector. The overall CO_2 emissions from clinker production would be reduced, as would the overall carbon intensity of the cement product. The quantity of CO_2 reduction that could be achieved depends upon the availability of technically suitable clinker substitutes and the level of substitution that is possible, which depends upon the outcome of the tasks and the type of cement product and concrete use prevalent in the market.

Action 3 Tasks

Task 3A: Carry out a study to identify alternative clinker substitute materials; impact of potential clinker substitutes availability and barriers, including the impact of decisions by UK Government concerning UK power generation and industry productivity on the availability of cement substitutes (ash and slag) and quantify the impact on the roadmap actions. The study should also include options such as ash tip reclamation and alternative supply routes for established clinker substitutes (e.g. importing ground granulated blast furnace slag and fly ash). The objective is to facilitate continuation / expansion of clinker substitution rates in UK cements despite reduction in supply of existing substitute materials from traditional sources.
Task Owner: BEIS, with input from MPA
Timing: 2018 - 2019

Task 3B: If credible technologies in task A are identified: consider demonstration of their technical performance in line with EU and UK standards.
Task Owner: Innovate UK/ MPA
Timing: 2020 onwards

Task 3C: If credible technologies in task A are identified: review and propose revisions to BSI and CEN standards to facilitate use of non-established clinker substitutes.
Task Owner: MPA
Timing: 2020 onwards

Task 3D: Review of suitability of ternary cement blends (i.e. cements containing clinker and two substitute components) using established clinker substitutes for use in UK construction and demonstrate applicability under UK and EU cement standards.
Task Owner: BEIS, with technical Input from MPA
Timing: 2018

Task 3E: Assess use of fly ash from combustion as alternative raw material for clinker production including technical, product quality and within the context of the circular economy.
Task Owner: InnovateUK
Timing: 2017 – 2020

Task 3F: Produce a report assessing barriers and enablers to deployment of existing novel low carbon cements, to understand what is currently limiting their deployment and how this may be overcome.
Task Owner: MPA
Timing: 2019

Task 3G: Monitor ongoing research and development of novel, non-Portland cements, based on non-traditional processes or raw materials through engagement with universities and patent holders / technology companies.
Task Owner: MPA
Timing: 2018 - ongoing

Task 3H: Depending on development of novel cements: demonstrate their technical and carbon performance.
Task Owner: MPA, working with BSI, CEN and academics
Timing: 2020+

Task 3I: Depending on development of novel cements: assess the standardisation requirements to make them ready for commercial use.
Task Owner: MPA, working with BSI, CEN and academics
Timing: 2020+

1.4 Action 4: To increase the deployment of state-of-the art energy efficient technologies in UK cement manufacture

- The 2050 roadmap for cement demonstrated that the majority of energy efficiency savings that can be made have already been implemented by the UK cement sector. Energy efficient technologies are part of the 'other' category in the cement roadmap because measures not already implemented have very long pay back periods, are technically complex, and can be capital intensive. This category under Current Trends could deliver between 8,000 and 280,000 tCO_2 reduction by 2050.
- In fact, delivery on some actions, particularly related to fuel switching, might make cement manufacture less energy and electrically efficient. For example, greater use of biomass fuels, with higher moisture content, can reduce energy efficiency and the use of a greater number of different fuels might increase electricity use in handling.
- The objective of the action is to reduce energy consumption where there is commensurate benefit in terms of CO_2 reduction associated with cement production. This will improve the sector's competitiveness as well as lowering carbon emissions. The action involves a number of short-term tasks that seeks to increase investment in energy efficiency measures where this is commercially viable and cost effective.

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Action 4 Tasks

Task 4A (cross-cutting): Run an Industrial Energy Efficiency Accelerator (IEEA) programme which is open to EIIs and worth £9.2m over four years. The accelerator will reduce energy costs for industry by funding the demonstration of close-to-market energy efficiency innovations and their wider roll out across the sector, while leveraging private sector investment.
Task Owner: BEIS
Timings: 2017 – 2021

Task 4B: Government to establish an industrial energy efficiency scheme to help large companies install measures to cut their energy use and their bills.
Task Owner: BEIS
Timings: 2017-2022

Task 4C: Encourage UK cement industry to take advantage of any new or existing public funding mechanisms to invest in cost-effective energy efficiency measures where commercially viable.
Task Owner: MPA in collaboration with BEIS
Timing: Ongoing

Task 4D: MPA to report publicly on the deployment of energy efficiency measures that deliver decarbonisation in the cement sector in their annual report.
Task Owner: MPA
Timing: Ongoing

Task 4E: BEIS to organise a working group to facilitate dialogue between the finance sector and the cement industry to explore how external finance could be used to support mature energy efficiency and decarbonisation investments, and to overcome the barriers to affordable external finance. The working group will set out its own Terms of Reference, including how frequently it should meet.
Task Owner: BEIS (MPA will lead on encouraging engagement from the cement sector, including identifying participants / individual businesses for the group).
Timings: 2017-2019

Task 4F: To engage with the cement sector to explore the potential for additional technologies, such as burners, process control, industrial boilers, heat recovery etc. which could be included in the Energy Technology List (ETL) to encourage wider investment opportunities through Enhanced Capital Allowances. The Carbon Trust is already doing a study to assess the potential for adding technologies to the ETL.
Task Owner: BEIS
Timings: 2017–2018

1.5 Action 5: To increase waste heat recovery in the UK cement sector

- Cement manufacture already utilises ‘waste’ heat to dry raw materials and fuels, enhancing the energy efficiency of the process. While the cement roadmap did not identify significant further opportunity to decarbonise using waste heat, this action aims to identify whether there are any cost effective opportunities to recover and use the low levels of remaining low grade waste heat.
- Industry and Government will collaborate to identify any industrial heat recovery projects that realise benefits for cement manufacturing sites in England and Wales. Government will support this by introducing an Industrial Heat Recovery Scheme. This will provide financial support for feasibility studies to identify opportunities for recoverable heat projects and assess their costs and benefits. It will also provide financial support for capital investment to help make industrial heat recovery projects commercially viable.
- The objective of the action is to identify any heat recovery projects, some of which companies will be able to take forward themselves, and some of which may be eligible for capital support from Government. It will help to tackle financial barriers to uptake, and realise economic and commercial potential for recoverable heat in the cement industry. Whilst there is not an opportunity to reduce primary energy demand in cement manufacture, there may be benefits overall in finding economic uses of waste heat by other domestic or non-domestic consumers.

Action 5 Tasks

Task 5A (cross-cutting): Government to introduce a financial support programme – the Industrial Heat Recovery Scheme (IHRS) – to boost industry confidence in and increase the deployment of industrial heat recovery technologies. The IHRS will provide: (i) match-funding support for onsite feasibility studies to increase knowledge and understanding of and identify opportunities for installation of industrial heat recovery technologies. This will help develop a pipeline of projects, some of which companies can take forward themselves, and some which may be eligible for capital support; (ii) capital support for industrial heat recovery investments, which have the potential to result in significant energy and carbon savings but which are not commercially viable by themselves.
Task Owner: BEIS, with input from industry
Timing: 2017 - 2021

Task 5B: Explore opportunities for use of low grade waste heat from cement sites
Task Owner: MPA and member companies
Timing: 2018 - 2021

1.6 Action 6: To highlight the role that the UK cement sector plays to enable carbon reduction across the value chain and in the built environment in the UK

- This action aims to implement a series of policies across Government and industry aligned to the carbon reduction opportunities across the value chain stemming from the cement sector.
- Concrete is a low carbon product that has high thermal mass properties, which, when used correctly in buildings, enables the storage and then slow release of heat. This has the effect of stabilising the temperature within a building so that less heating is required in winter and less cooling is required in summer, but the benefits are year-round as the diurnal temperature cycle peaks are reduced. This in turn reduces the energy demand of buildings such that the embodied carbon dioxide of a typical building can be "paid off" within 11 years[15]. This 'demand side flexibility' offered by heavy weight buildings could be a key solution to the growing imbalance between energy demand and renewable energy generation[16]. As space heating alone accounts for around 20 to 50 per cent of a building's energy consumption depending on type[17], and around a third of the carbon emissions from all UK buildings[18], concrete can make a valuable contribution to reducing emissions in residential and service sectors.
- The objective of the action is to enable carbon reduction benefits resulting from the application of cement and concrete products to be facilitated across the value chain on a whole life basis and the adoption of materially efficient processes within the sector.
- Government is keen to see producers and supply chains use their knowledge and expertise to ensure responsible resource use across the supply chain, to help drive down energy costs, boost energy productivity and find new ways to cut down unnecessary waste.The Government's industrial strategy will consider how energy costs can be contained or reduced by increasing resource and energy productivity

[15] The Concrete Centre "Thermal Mass for Housing", 2006
[16] 3E Report for CEMBUREAU (The European Cement Association), "Structural thermal energy storage in heavy weight buildings- analysis and recommendations to provide flexibility to the electricity grid", October 2016
[17] Part L Review 2010: IAG briefing note, November 2008
[18] INGENIA, Issue 31, Building Research Establishment, June 2007

- The action includes a series of short-term tasks that seek to address policy barriers that hinder the implementation of whole life decarbonisation opportunities linked to the UK cement sector. Implementation of this action will create a business and legislative environment that is conducive to the application of industrial decarbonisation across UK industry and specifically within the cement sector and its value chain.

Action 6 Tasks

Task 6A (cross-cutting): Embed the use of the Growth Balanced Scorecard for all major projects above £10m to allow more straightforward matters such as cost to be balanced against more complex issues such as social and wider economic considerations. This type of approach will help to achieve Government's key objectives, like sustainable economic growth. The Growth Balanced Scorecard enables economic, social or environmental considerations to be taken account of in procurement design, technical specifications, award criteria and contract performance conditions linked to the subject matter of the contract, including sustainability and whole life costing of materials.
Task Owner: Government departments
Timing: 2017 - 2020

Task 6B: UK Government and cement industry to assess the positive and negative implications of the circular economy on the decarbonisation potential of the UK cement sector, as part of the work on the Industrial Strategy, to explore opportunities to reduce raw material demand and waste in our energy and resource systems, including using resources in the most efficient manner.
Task Owner: BEIS
Timing: 2017-2018

Task 6C: UK cement industry to work in partnership across construction sector to develop and implement Resource Efficiency Action Plans (REAPs) for cement-containing construction products.
Task Owner: MPA, The Concrete Centre
Timing: 2018

Task 6D: Improve skills in architecture to utilise the thermal benefits of concrete.
Task Owner: MPA The Concrete Centre
Timing: 2018 – 2021

Task 6E: Quantify and report on the CO_2 and material efficiency performance of cement and concrete.
Task Owner: MPA
Timing: 2017

Task 6F: UK cement industry to analyse and publish the recycled content of cement alongside plans for increasing recycled content in order to quantify the fossil fuel, natural raw material and CO_2 savings
Task Owner: MPA, supported by cement companies
Timing: 2017 – 2018

Task 6G: Explore and agree whether there is a need to improve the current government evidence base on costs of delivering decarbonisation in cement industry. This exercise could provide better quality data for modelling decarbonisation scenarios. : (i) further substitution of clinker in cements (ii) lowering cement content in concrete (requires development and agreement of new cement and concrete standards (iii) Alternative or novel cements (iv) material efficiency / smart design / specification in end-use applications to reduce quantities of concrete (and therefore cement) within construction projects. The output will further develop the understanding of the need for and scale of other technology routes such as CCS/U.
Task Owner: BEIS supported by MPA and academics
Timing: 2018

Task 6H (cross-cutting): Government will work with stakeholders to promote well-functioning markets for secondary materials, and new disruptive business models that challenge inefficient practice.
Task Owner: BEIS
Timing: Ongoing

Task 6I: The Government will set out a long term vision for delivering a more resource efficient and resilient economy in its 25 Year Environment Plan, following engagement with the cement sector.
Task Owner: Defra with input from MPA
Timing: Ongoing

1.7 Action 7: Minimising business energy costs to support investment in the UK's cement sector

- Government is committed to ensuring energy is affordable for households and businesses, and that the shift to a low carbon economy is done in a way that minimises the cost to UK businesses, taxpayers and consumers.
- During the last five years action has been taken to reduce the impact of policies on the electricity bills of eligible energy-intensive industries up to around 80 per cent – although the cement sector is not eligible for all of this relief. This mitigation – including compensation worth around £260 million for 2016 – is paid either by other consumers or the taxpayer. The Government continues to work on improvements to the package of compensation and exemption available, including working with the EU to transition from compensation to an exemption scheme for the costs of the Renewables Obligation/Feed in Tariff and assessing options to provide compensation to direct competitors of eligible energy intensive businesses.
- The difference between UK industrial electricity prices and those of other European countries is now mainly due to our higher wholesale prices and network costs. The Industrial Strategy's commitment of a roadmap to minimise business energy costs will explore ways of reducing these costs in a sustainable way. Government will also continue to seek to mitigate the impact of a lack of global harmonised carbon price, including through working to ensure adequate protection against the risk of carbon leakage.

Action 7 Tasks

Task 7A (cross-cutting): Government will commission a review of the opportunities to reduce the cost of achieving our decarbonisation goals in the power and industrial sectors. This will include how best to support greater energy efficiency, and how Government can best work with the regulator Ofgem to ensure markets and networks operate as efficiently as possible in a low carbon system.
Task Owner: BEIS
Timing: 2017-2018

2. Case Studies

Project	**Carbon Capture and Storage/Utilisation in the Cement Sector: Several projects investigating how best to capture CO2 emitted in cement production, in order for it to be utilised or stored.**
Relevant Action(s) No.	Action 4: To facilitate the deployment of carbon capture utilisation and storage (CCUS) in the UK cement sector.
Description	The manufacture of cement results in the emission of greenhouse gases from two sources; 1. Around 30% of the emissions are from the combustion of fuels used to generate temperatures of 1,450°C in a kiln to heat the raw materials; and 2. The remaining 70% of emissions arise from the chemical decomposition of the raw materials, typically limestone or chalk - termed 'process emissions'. Combustion emissions can be reduced through technologies such as the use of biomass fuels but a significant reduction of process emissions will only be possible through the use of carbon capture and storage/utilisation technology. In the cement sector the two most applicable carbon capture technologies are oxyfuel and post-combustion capture. Oxyfuel requires oxygen to be separated from air prior to combustion and then the oxygen is used for the combustion of fuels. This produces very high concentrations of CO_2 in the exhaust gases, which is easier to purify and capture. Post-combustion capture uses a suitable solvent to absorb the CO_2 from exhaust gases. The absorbed CO_2 is liberated from the solvent before being compressed for transport and storage/utilisation. The European Cement Research Academy (ECRA) CCS Project was started in 2007 as a long-term project to assess the technical and economic feasibility of the application of CCS/U technologies to the cement industry. ECRA has also been cooperating with the Norcem Brevik cement plant in Norway where different post-capture technology providers have been testing their technology under realistic conditions The Norcem project consists of four individual technologies: • Solid sorbent technology by RTI • Amine technology by Aker Solutions • Membrane technologies by a consortium under the lead of the Norwegian University of Science and Technology • Carbonate looping by Alstom Power

Project	**Carbon Capture and Storage/Utilisation in the Cement Sector: Several projects investigating how best to capture CO2 emitted in cement production, in order for it to be utilised or stored.**
Description (cont.)	ECRA are also involved in another project known as CEMCAP[3]. This project is funded by Horizon 2020 and addresses CO_2 capture from cement production by the demonstration of different CO_2 capture technologies in an industrially relevant environment based on the previous work of ECRA and Norcem. CO_2 capture technologies with the greatest potential to be retrofitted to existing cement plants will be identified. The project duration is from 2015 to 2018. ECRA is involved on the industrial advisory group to give guidance to the research consortium and communicate the results within the European cement industry. Another project underway in the cement sector is the LEILAC[4] (Low Emissions Intensity Lime and Cement Manufacture) project, which is piloting a Direct Separation technology. This separates the pure CO_2 from the chemical decomposition of limestone (process emissions) from combustion emissions, enabling the pure CO_2 to be captured. In October 2016 the project completed the Preliminary Front End Engineering Design and is now entering the full Front End Engineering Design (FEED) phase.
Opportunities	The Cement Sustainability Initiative[5] has identified a number of emerging CCU technologies that are applicable to the cement sector. These are: 1. Use of captured CO_2 as a feedstock for the synthesis of chemicals or special polymers including urea and formic acid. 2. Use of CO_2 for the production of methane. 3. Use of CO_2 for the production of methanol or fuels. 4. Use of CO_2 in Enhanced oil recovery (EOR), to increase the recovery of oil in depleted or high viscosity oil fields. This has the added benefit of the CO_2 then being stored in the depleted oil field. 5. Capture of CO_2 by algae, which is then processed to produce fuel. Much of the work that has been done so far has looked at how to capture and utilise CO_2. Considerable cross-sector work is required on transportation networks for captured CO_2 to its point of storage or use. Furthermore, technologies for storage of CO_2 also require considerable research.
Outcome and benefits	
Lessons Learnt	

Project	**Carbon Capture and Storage/Utilisation in the Cement Sector: Several projects investigating how best to capture CO2 emitted in cement production, in order for it to be utilised or stored.**
Cost of implementation	£millions; for example the LEILAC project has cost in the region of €21m so far, €12m of this came from the European Union's Horizon 2020 research and innovation programme.
Year	The ECRA CCS project comprises five stages, the first three are complete and the fourth is underway . 1. Phase 1 (January to June 2007): literature and scoping study. 2. Phase 2 (2007 to 2009): studies on the technical and financial aspects of CCS projects. The main objective of this phase was to perform studies for CO_2 capture at the clinker burning process, focusing on oxyfuel and post-combustion measures. Research activities focused on investigations regarding solvent regeneration, flue gas characteristics, plant layouts, cost estimates, oxygen supply, process modelling, CO_2 purification and compression. Initial laboratory trials were also carried out to assess the influence of oxyfuel combustion on the burning process. 3. Phase 3 (2009 to 2011): detailed examinations of oxyfuel and post-combustion capture technologies. The oxyfuel combustion work packages included process simulation, burner design, refractory lining optimisation and general layout for a flue gas conditioning facility for a rotary cement kiln. The post-combustion work packages included simulations of amine-based absorption processes, laboratory experiments on absorbent degradation and concept and pre-engineering and design bases for pilot trials. 4. Phase 4 (currently underway, 2 -3 years): Prepare pilot plant 5. Phase 5 (time-frame, 3 -5 years): Build and operate pilot plant 6. Phase 6 (time-frame, 3 -5 years): Demonstration plant
References	Carbon Capture and Storage Association, http://www.ccsassociation.org/ [2] Text from Global CCS Institute, https://www.globalccsinstitute.com/projects/ecra-ccs-project and ECRA, https://www.ecra-online.org/226/ and steering committee presentation from meeting on 8th July 2014. [3] CEMCAP, https://www.sintef.no/projectweb/cemcap/ [4] LEILAC, http://www.project-leilac.eu/ [5] Cement Sustainability Initiative,
Contact	

3. Glossary

	Definition
Action	An activity that will be delivered through a series of separate tasks
Task	A specific piece of work to deliver an action
Clinker	Hard substance that chemically combines crushed and heated limestone or chalk, with small amounts of other natural materials, essentially changing calcium carbonate (CaCO3) to calcium oxide (CaO) which then reacts with silica (SiO2) to form calcium silicates.
Impact	A qualitative or quantitative description of the impact on carbon, financial or competitiveness as a result of successfully implementing the action
Dependency	How one action might influence another action, for example a shorter term action may be linked to longer term actions or ambitions.
MPA Concrete Centre	The Concrete Centre provides material, design and construction guidance. Its aim is to enable all of those involved in the design, use and performance of concrete and masonry to realise the potential of the material.
Novel Cements	Cements which are generally non-Portland, based on non-traditional processes or raw materials. They tend to embody less energy and emit less CO2 during manufacture than 'Portland cement CEM I'.
Resource Efficiency Action Plan	Action Plans with practical recommendations, actions and targets that will directly benefit industry by increasing the opportunity for recycling and reusing recovered materials.
Resources	Staff or funding required to deliver a specific task
Objective	The impact on strategic outcome of the action (e.g. increased energy efficiency in xx sector – or the objective is to decarbonise and do this using CCS technology and a transport and storage network).
Output	[Tangible] Result achieved by the action being undertaken (e.g. better awareness amongst industry managers of opportunities etc) – an Emphasis on the overall action delivery or result – e.g. delivers Carbon capture network so that industry can use it to capture and store carbon.
Short Term Action	Action that will be undertaken between 2017 and 2020

	Definition
Longer Term Action	Action that will take place beyond 2020
Barrier	A factor that needs to be overcome for an action to be achieved
Waste derived biomass fuel	Single waste streams that contain 100% or part biomass including tyres, meat and bone meal and paper sludges
Mixed waste streams containing biomass	Mixed waste streams that are used to produce fuel including refuse derived fuel.
Sustainably sourced biomass	'Virgin' biomass such as wood that is certified as sustainably sourced e.g. through the standards produced by the Sustainable Biomass Program. Currently the cement sector does not use any 'virgin' biomass sources.