Modernization and Innovation in the materials sector:
lessons from steel and cement

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About Climate Strategies

Climate Strategies is an international organisation that convenes networks of leading academic experts around specific climate change policy challenges. From this it offers rigorous, independent research to governments and the full range of stakeholders, in Europe and beyond. We provide a bridge between research and international policy challenges. Our aim is to help government decision makers manage the complexities both of assessing the options, and of securing stakeholder and public consensus around them. Our reports and publications have a record of major impact with policy-makers and business.

Modernization and Innovation in the Materials Sector: Lessons from Steel and Cement

By Karsten Neuhoff, Andrzej Ancygier, Jean-Pierre Ponssard, Philippe Quirion, Nagore Sabio, Oliver Sartor, Misato Sato and Anne Schopp.

Since 2007, the European cement and steel sectors have been characterized by substantial surplus production capacity. Hence re-investment in primary production of many materials remains limited and endangers the longer-term economic viability of many plants. Opportunities for innovation and modernization could overcome these challenges. They are linked to new demands for more efficient and lower-carbon production processes, higher-value materials with less weight and carbon intensity, and new applications in construction, transport and the energy sector. Only a limited share of these opportunities has been captured so far, which can be attributed to the policies implemented to date.

For the future realization of innovation and modernization opportunities, a clear longer-term perspective is required in three policy elements. First, an effective carbon price emerging from the European Union Emissions Trading System (EU ETS) that is relevant both for producers, to facilitate switching to lower-carbon production, and also for intermediate and final consumers to create a viable long-term business case for large-scale investments in lower carbon processes, materials, and efficient use. Second, public funding for the innovation and demonstration of breakthrough technologies. Third, institutional arrangements including aspects like norms and standards as well as provisions for training of craftsmen need to be adjusted to enable the use of new production processes and materials.

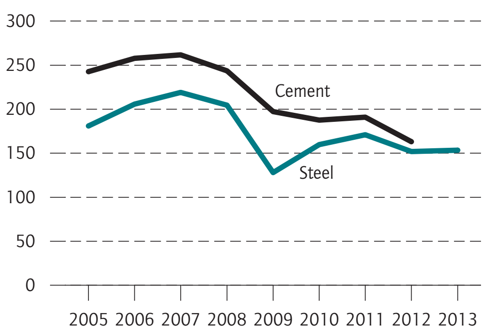
Between 2007 and 2012, carbon-intensive materials like steel and cement faced in Europe a decrease in real consumption by more than 30 percent (Figure 1). Only a proportion of pre-crisis demand is expected to be recovered in the coming years.

This decrease resulted in low margins and losses that will persist until the production capacity better matches demand, most likely through closures (Figure 2). Although all of this is not linked to climate policy, it does limit opportunities for reinvestment and thus requires attention in order to avoid putting the longer-term viability of European installations at risk. Financial challenges that result from oversupply can distract management from long-term strategies, thus requiring additional effort to engage the sectors in the development of low-carbon roadmaps.

In 2012, around 15 percent of industrial greenhouse gas emissions in Europe originated from iron and steel pro-

Figure 1

Consumption of steel and cement in Europe (EU-28)
In million tons finished products

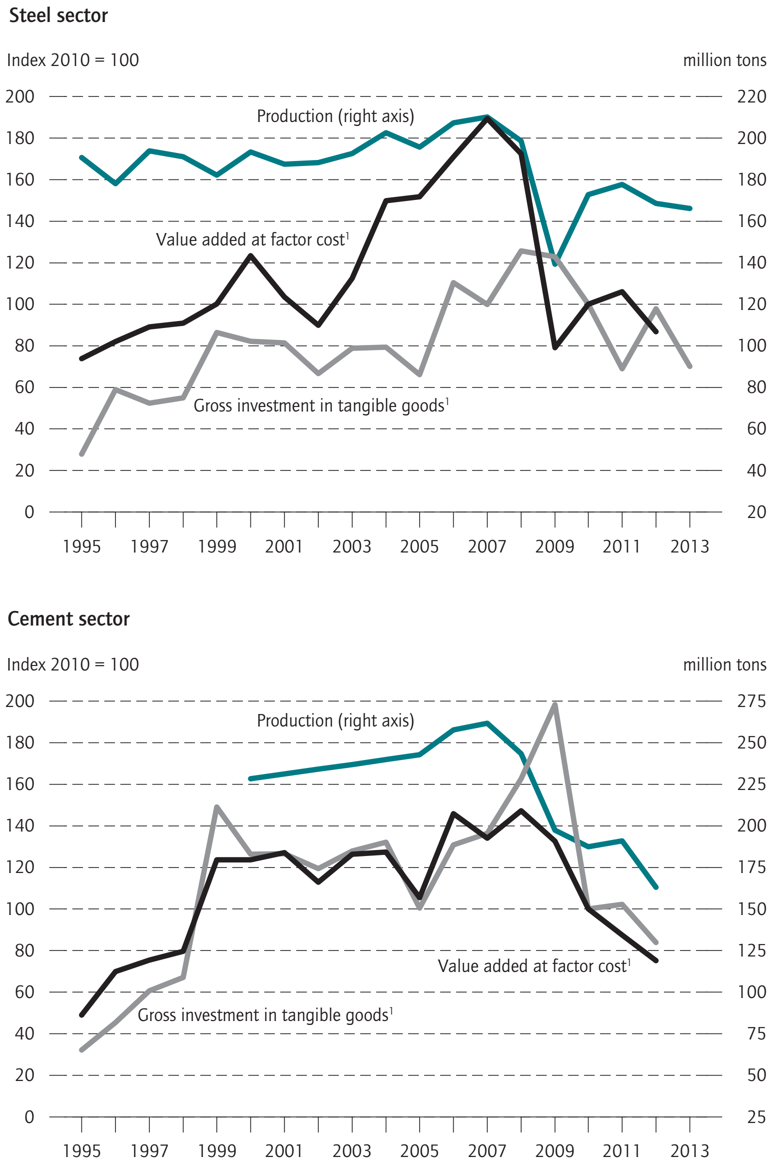


Sources: Cement Sustainability Initiative, World Steel Association.

Demand for steel and cement remains below pre-crisis levels.

Figure 2

The European steel and cement sectors



1 Calculated using all available information on the respective statistics of the individual EU-27 countries. All values in prices of 2010.

Source: Own calculations based on Eurostat, World Steel Association and Cement Sustainability Initiative data.

Gross investment remains well below pre-crisis levels.

duction and another 23 percent from cement production.[1] Other carbon-intensive materials include pulp and paper, plastics, and non-ferrous metals like aluminum and copper. In these sectors, most emissions are associated with primary materials production, e.g. hot-rolled steel from iron produced in blast oxygen furnaces.[2] This needs to be taken into account when assessing which policy framework can most effectively leverage mitigation opportunities. Such a policy package must be placed in the context of the 2030 emission reduction targets, as well as the deeper emission reductions following 2030 that were confirmed at the G7 meeting in June 2015.[3]

A two-year European Research Project reviewed the experience of the steel and cement sectors with a portfolio of innovation and modernization opportunities so as to assess the role of different market and policy drivers (Box). Our analysis assesses the investment framework in the iron and steel and cement sectors in particular and analyzes the extent to which a well-designed policy package could help attract investment and contribute to an economically and environmentally sustainable development of the European materials sectors.[4]

A portfolio of modernization opportunities for the steel and cement sectors

The aggregated picture within the steel and cement sectors has been blurred by the economic crisis in Europe. For this reason, it is important to uncover the individual developments beyond the aggregated sector trends. Figure 3 shows a number of different modernization and innovation options that can save resources, energy, and carbon emissions in the steel and cement sectors. These can be grouped into: (i) energy efficiency improvements resulting from a lower utilization of energy per unit of product; (ii) CO_2 efficiency improvements by reducing the carbon intensity of fuels or breakthrough technologies such as carbon capture and sequestration (CCS) or carbon capture and use (CCU); and (iii) more efficient use of materials, and the use of less carbon-intensive materials.

Potential for energy efficiency improvements is limited

Energy costs are a significant component of the overall costs of production for carbon-intensive materials like steel and cement. Hence energy efficiency improvements have long been the focus of management and are better understood here than in other parts of industry. However, potentials for energy efficiency improve-

1 According to EEA greenhouse gas data provided in 2015. In the following, iron and steel production is more concisely referred to as the steel sector.

2 International Energy Agency (2007): Tracking Industrial Energy Efficiency and CO_2 Emissions. IEA/OECD. Paris.

3 In early June, the G7 leaders released a joint communiqué that reaffirms their previously stated goal of limiting global warming to less than 2 degrees Celsius above pre-industrial levels.

4 The authors are grateful for the support of Chris Beauman.

Box

The Climate Strategies project "Carbon Control Post 2020 in Energy Intensive Industries"

This report summarizes the insights from the research project "Carbon Control Post 2020 in Energy Intensive Industries", led by the German Institute for Economic Research (DIW Berlin) and convened by Climate Strategies (www.climatestrategies.org). Climate Strategies is a not-for-profit organization that works with an international network of experts to bridge the gap between academic research and policy and to provide unrivalled analyses for international decision-makers in the fields of climate change and energy policy.

The project is funded with support from the governments of France, Germany, the Netherlands and the United Kingdom as well as from Heidelberg Cement and Tata Steel Europe. The views expressed and information contained in the report are independent perspectives of researchers and not necessarily those of or endorsed by the funders.

Project partners of DIW Berlin were CNRS-Ecole Polytechnique, Centre International de Recherche sur l'Environnement et le Développement (CIRED), The Institute for Sustainable Development and International Relations (IDDRI) (all France), Hertie School of Governance, University Erlangen-Nürnberg (both Germany), Radboud University Nijmegen (the Netherlands), The Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Sciences, and University College London (both United Kingdom).

A first report on the cement sector was published in February 2014, followed by a second report on the steel sector in October 2014.[1] Both reports combine a literature review, data analyses, a legal review, in-depth interviews with selected senior managers of steel companies, extensive discussions with several CEOs, and workshops with representatives of governments, the European Commission, non-governmental organisations, and industry.

1 See also Neuhoff, K., Vanderborght, B. et al. (2014): Carbon Control and Competitiveness Post 2020: The Cement Report. Climate Strategies. London, February 2014; and Neuhoff, K., Acworth, W. et al. (2014): Carbon Control and Competitiveness Post 2020: The Steel Report. Climate Strategies. London, October 2014.

ments of primary steel and cement production with existing technologies are estimated to be in the order of only 10–20 percent for European installations. They are pursued only where investment costs are covered by energy and carbon cost savings and paid back within 2–4 years.[5] Such short payback periods for cost-saving measures are common requirements for industry actors.

In energy-intensive industries, most energy efficiency savings will mainly be realized as part of large-scale refurbishment or replacement investments, but such opportunities are limited due to the combination of long investment horizons, low demand, and excess capacity in Europe, leading to a slow replacement of existing stock.

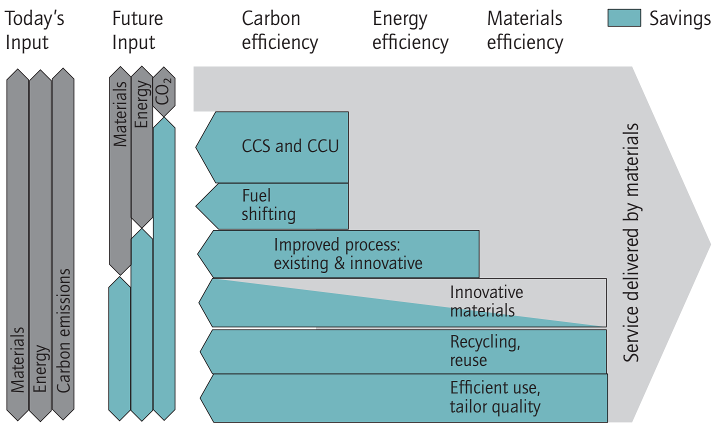
Many fuel-switching options have already been implemented

The cement sector reduced fuel-related carbon intensity— which constitutes about one third of the sector's to-

5 Neuhoff, K., Vanderborght, B., et al. (2014), l.c. and Neuhoff, K., Acworth, W., et al. (2014), l.c.

Figure 3

Multiple benefits of modernisation and innovation opportunities for materials and energy input and CO_2 emissions



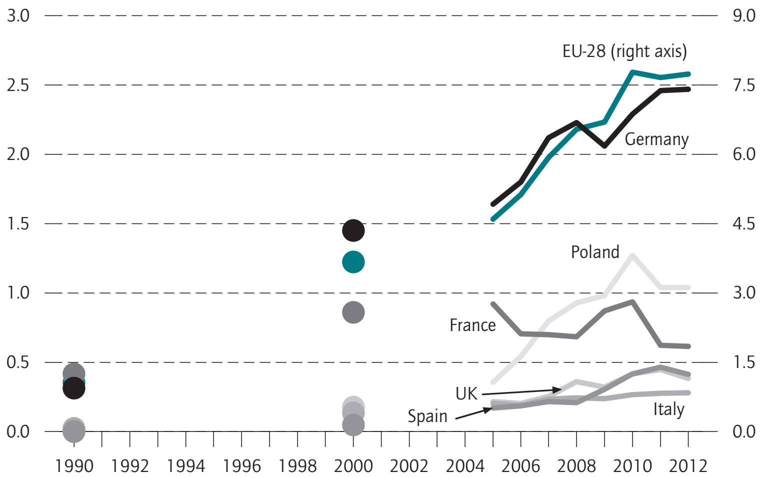
Source: Own illustration.

A portfolio of modernization and innovation opportunities facilitates large-scale emission reductions as well as savings of material and energy.

Figure 4

Use of alternative fossil fuels[1] in the cement industry

In million tons



1 Alternative fossil fuels are derived from waste, excluding biomass waste.

Source: Cement Sustainability Initiative, GNR Indicator 313.

The use of alternative fuels has increased substantially.

tal emissions—by 6 percent between 2005 and 2011.[6] This was achieved by replacing 9 percent of coal with biomass residue that is considered carbon neutral according to EU ETS accounting standards. In addition, co-firing pre-treated waste products with lower carbon intensity than coal played a role in lowering the energy carbon footprint after the European Union Waste Framework Directive was implemented (see Figure 4). As regulatory constraints are removed, both of these options become commercially attractive, as the high incineration temperatures of cement kilns allow the sector to switch to waste products as fuel sources rather than incurring costs for acquiring fossil fuels.

In the steel sector, shifting away from coal to natural gas and electricity with the Direct Reduced Iron process (DRI) combined with Electric Arc Furnaces (EAFs) reduces carbon emissions of primary steel production by between 20–40 percent.[7] However, the economics of DRI depend on the combination of coal, gas, and carbon prices. The current combination of high gas prices with low coal and carbon prices makes DRI economically unattractive in Europe, but it could play a future role as part of innovative process technologies.[8]

In both of these sectors, around two-thirds of the emissions are linked to process emissions from the chemical transformation of limestone into clinker (in the case of cement), or the reduction of iron ore to raw iron (in the case of steel). Process emissions will not be reduced by fuel shifting to lower carbon fuels and energy efficiency improvements: they can only be reduced by breakthrough technologies.

Promising new process technologies not available on a commercial scale

Breakthrough technologies including CCS or CCU, are being explored to combine efficiency improvements and large-scale emission savings compatible with long-term carbon constraints.

For steel, the potential for such breakthrough process technologies has been explored as part of the European Ultra-Low Carbon Steelmaking (ULCOS) consortium, initiated in response to carbon constraints expected from climate policy. Outside of Europe, similar initiatives have been developed. So far, this has resulted in three small-scale demonstration projects for different technology options funded jointly by public and private sectors. However, further progress has advanced at a slower pace since 2012, primarily because the initial funding was not continued—it would have needed to be expanded in order to match increasing investment needs for a stepwise scale-up of demonstration plants towards the commercial scale.

The NER 300 program[9] uses the revenues from the sale of European Union Allowances to new entrants in the EU ETS as a means to fund innovation in CCS and renewable energy projects. This represents an additional opportunity for funding innovation in new low-carbon technologies and processes. However, the opportunities that were provided from the NER 300 fund were

6 For a detailed analysis, see: Branger, F., Quirion, P. (2015): Reaping the Carbon Rent: Abatement and Overallocation Profits in the European Cement Industry, Insights from an LMDI Decomposition Analysis. Energy Economics 47, 189–205.

7 International Energy Agency (2013): Overview of the current state and development of CO_2 capture technologies in the iron-making process. IEAGHG Report 2013/TRG.

8 According to recent research, DRI is currently being considered in the United States as well as in Japan. See: Fischedick, M. et al. (2014): Technoeconomic evaluation of innovative steel production technologies. Journal of Cleaner Production 84, 563–580; and Pinegar H. K., Moats, M.S. et al. (2011): Process Simulation and Economic Feasibility Analysis for a Hydrogen-Based Novel Suspension Ironmaking Technology. Steel Research International 82, 951–963.

9 The NER 300 program has been established by the revised Emissions Trading Directive 2009/29/EC. According to article 10(a) 8, proceeds from the sale from up to 300 million allowances should be used to finance commercial demonstration projects in the area of CCS and renewable energies. For further information on the EU NER 300 program, see http://ec.europa.eu/clima/policies/lowcarbon/ner300/documentation_en.htm.

considered too risky by many CCS project promoters, since any support for a demonstration project would have had to have been returned in the event that the technology failed.[10] Steel and cement companies struggle to bear the full risk of unknown breakthrough technologies, particularly because there are large technology spillovers that cannot be captured by the companies. This experience needs to be taken into account in the design of the new European Union innovation financing arrangements, given that the October 2014 European Council conclusions explicitly open the future Innovation Fund to also support low carbon innovation in the manufacturing and thus materials industry. Aside from the funding issue, the lack of public support for CCS in the power sector in some Member States is a concern, and points to the importance of effective early engagement strategies with the broader public.

For steel companies to fully re-engage in innovative process technologies, a long-term business case for a large-scale rollout of new technologies after the demonstration phase will also be important. As most of the process technology options involve CCS, and thus higher investment and operational costs, a clear perspective on how companies can recover high costs is necessary. This will need to be addressed in the design of the EU ETS carbon leakage protection measures post-2020.[11]

Tailored use of materials saves energy, carbon, and resources

Tailoring materials to their specific application can allow for the delivery of the same service with lower energy, carbon, and resource usages. For example, when the automotive sector had to reduce the weight of cars to meet fuel efficiency standards in the 1990s, the steel industry innovated and further tailored steel to specific industry-led demand. With high-strength steel and new forming techniques, the steel sector achieved about 25 percent savings in automobile body weight, which has been the case since 2005.[12] This reduces total emissions, as emissions from steel production are largely proportional to the weight of the steel. While such a shift from volume to value of steel will decrease the demand for primary steel production, it might provide higher margins and job opportunities in higher-value products.

Such progress has not been achieved for steel or cement use in the construction sector.[13] Significant mitigation potential exists in the construction sector through more efficient steel and cement use: for example, by using tailored shapes, supporting multiple loads with fewer structures, aligning loads to avoid bending, and avoiding over-specification of loads.[14] A clear and credible carbon price in steel and cement product prices is likely to encourage more tailored procurement of carbon-intensive materials in the construction industry. However, this will depend as much on the adaptation of building practices, standards, and information systems—and can require provision of information, e.g. with labeling approaches and reporting requirements—as on the training and certification of different actors. This will also require significant coordination across the value chain.

Innovative materials – high potential but limited incentives

Introducing innovative materials has considerable potential for emission reductions, but it is a challenging process, as evident from experiences with clinker substitutes in cement. While the main chemical basis for cement is clinker derived from limestone, some clinker may also be substituted with slag (a by-product of steel production) or fly ash (a by-product gathered from exhaust streams of coal-fired power plants) (Figure 5). However, substituting by-products for limestone was initially met with resistance from the construction industry due to alterations to the technical qualities of the concrete that was produced (such as the level of early and late strength, sulfate resistance, color, and workability). This may have delayed the adjustment of codes and standards for concrete and buildings that previously created requirements for high shares of clinker, and thus secured demand from installations of incumbent companies. This reluctance has been overcome through engagement with the construction industry—for example, by means of demonstration projects and knowledge sharing of positive experience with new materials.

The availability of clinker substitutes in Europe varies across regions. While the potential of using slag from steel production is largely exhausted, some potential for using fly ash from coal power stations in the power sector remain. The shift away from coal in the power sector

10 In other regions, such as Japan, efforts continue to progress through the COURSE50 program and exploring the synergies of low-carbon innovative options with alternative energy vectors such as hydrogen.

11 Carbon leakage protection refers to special provisions to avoid the risk of relocation of producers that bear large incremental costs from carbon pricing. For further details, see in the same issue Neuhoff, K., Acworth, W. et al. (2015): Leakage Protection for Carbon-Intensive Materials Post-2020. DIW Economic Bulletin 28+29/2015.

12 Zuidema, B.K. (2013): On the Role of Body-in-White Weight Reduction in the Attainment of the 2012–2025. US EPA/NHTSA Fuel Economy Mandate. Presentation to the Great Design in Steel Seminar. United States.

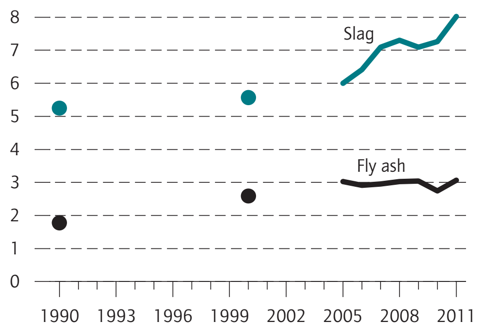
13 Giesekam, J., Barrett, J. et al. (2014): The greenhouse gas emissions and mitigation options for materials used in UK construction. Energy and Buildings (78), 210.

14 Allwood J. M. et al. (2012): Sustainable Materials: with both eyes open. Cambridge, UK: UIT Cambridge.

Figure 5

Use of selected clinker substitutes in European cement production

In percent of total cement volume



Source: Cement Sustainability Initiative, GNR Indicator 3219.

Subsituting away from clinker reduces emissions but also changes the composition of the cement.

will, however, reduce fly ash availability. Other clinker substitutes can further decrease the clinker ratio in EU cement production (for example pozzolana).

A variety of new low-carbon cement alternatives are being investigated. Any such innovative low-carbon cements are not expected to provide the very same functions as conventional cement. Instead they might be used—and possibly preferred—according to the relative importance of soundproofing, different stability requirements, and fire protection. A further rationale for a more differentiated set of low-carbon cement types might emerge from the limited availability of resources, as few suitable materials are as accessible as limestone.

Low-carbon cement options include "new" cements based on "old" ideas, such as calcium sulfoaluminate cement, clinker mineralization, as well as other new products. Cement sector executives argue that developing and demonstrating such new products will take 10 to 15 years. Perhaps the most important barrier for product innovation is the absence of market demand for products with lower embedded carbon, especially as long as carbon prices are low and not reflected in cement prices. Even with carbon prices included in cement costs, it will take time, and the process of encouraging users to make the shift to new cement types will be gradual: the use of cement and concrete for infrastructure with a very long lifetime, particularly foundations and buildings, makes proven durability of the cement a necessity.

Focus extending from quantity to also quality of recycled materials

A ton of scrap steel collected and recycled saves about 75 percent of emissions compared to a ton of newly produced steel.[15] A maturing economy increasingly replaces rather than adds buildings and cars, and thus the volume of recovered scrap in Europe already equals 64 percent of European steel consumption.[16] This rate will increase further as the economy continues to mature, thus gradually reducing the demand for primary steel production.

While almost 100 percent of steel from the automotive sector and structural components in construction is later recycled, there is still potential for improvement of recycling rates for reinforcement steel in construction, packaging, and appliances. Action is required not only at the recovery stage, but also during the primary steel production and design stages in order to facilitate better separation and recovery of different materials down the value chain, thus enhancing the recyclability of the collected scrap.

While mature OECD economies collect larger volumes of scrap than do emerging economies, they also retain a large capacity for primary steel production. Hence about 20 percent of European Union scrap is exported, and replaces primary steel production in emerging economies. Thus using more of this collected scrap in Europe instead of exporting it would decrease carbon emissions in Europe in the short run, but lead to an equivalent emission increase outside of Europe. Globally and over time, however, improving steel recovery and increasing recycling volumes are likely to form part of the solution to curb steel emissions, together with other strategies such as extending the life of steel products, diverting scrap to other uses before recycling, and reusing metal components without melting them and converting them into new products.

While steel recycling creates material of similar quality, recycling of other materials only allows for lower-quality products (paper, glass) or very low-quality products (some plastics, concrete). Some materials also create economic and environmental costs when treated at the end of their lifetime. This is reflected in total life cycle assessments of materials. It remains debated how the lifetime emissions concept should best be reflected in carbon, resource efficiency, or other environmental policies, so as to provide the appropriate incentives for material choice to producers and consumers.

15 Average CO_2 emissions in the EU: 1888 kg CO_2/ton for integrated steelmaking and 455 kg CO_2/ton for secondary steel route. EUROFER (2013): A Steel Roadmap for a Low Carbon Europe 2050. EUROFER.

16 Genet, M. (2012): EAF and/or BOF. Which route is best for Europe? Presented at the 8th Steel Markets Europe Conference. Brussels. May 2012.

Implications for future policy design

The realization of the various opportunities for innovation and modernization depends on a suitable policy framework.

CO_2 price signal for producers needs to be strengthened

Capital-intensive investments in the steel sector require long-term decision and investment periods. Viable returns over more than a decade must also be ensured. Hence early clarity on longer-term perspectives, especially for large scale-investment projects and the development of new low-carbon technologies and materials, is essential.

Technological opportunities are inherently uncertain and hence it is impossible for the industry to commit to, and for the governments to prescribe, a precise emission trajectory for any one individual sector. This points to the value of coverage of emissions across a number of sectors: It provides a credible commitment to an overall emission reduction trajectory, while offering the flexibility to respond to technology developments at the sector level.

Long-term carbon constraints will only obtain credibility and enhance the investment framework if today's carbon prices are consistent with the long-term expectations. As such, the decline of the EU ETS carbon price from 30 €/t in 2008 to 5–10 €/t in recent years significantly reduced the credibility of the EU ETS and virtually eliminated the incentives created through the scheme. This has been broadly recognized and is the motivation for the Market Stability Reserve that will be in effect from 2019 onwards.

CO_2 price signal needs to be preserved for intermediate and final consumers

To avoid risks of carbon leakage, installations in the cement and steel sectors receive allowances for free, based on historic activity levels and emission benchmarks.[17] This use of ex-ante free allocation as a leakage protection mechanism has resulted, in the steel and cement sector, in a low and uncertain carbon price pass through to intermediate and final consumers.

However, the business case for low-carbon process technologies and materials requires that the carbon price be reflected in the price of carbon-intensive materials. Thus the CO_2 costs are taken into account in consumer choices among materials, more efficient uses, and substitutes. In many instances it will not be the final consumers, but rather the intermediate consumers like the automotive or construction industries that will make the decisive choices—but they will do so in light of the total costs ultimately borne by final consumers.

The full reflection of carbon costs in the price of carbon-intensive materials is also important for allowing the producers of alternative low-carbon production processes to account for incremental production costs in the price of their product, and thus allow them to foresee longer-term perspectives for cost recovery and economic viability of new production processes.

An effective carbon price in the value chain is necessary to provide a credible perspective for the large-scale use of innovative materials and production processes. This is a necessary condition for companies to allocate resources and dedicate management and research capacity. This points to the importance of exploring new approaches to carbon leakage protection that preserve the carbon price signal for intermediate and final consumers.

Breakthrough technologies require financial support

Product and process innovation has very different features with respect to the scale of investment required and the timeframe over which new technologies are commercially applicable. For successful product innovation, the close link to consumers is essential. Short timeframes from development to market implementation and clear product differentiation for the consumer allow for largely private sector-funded innovation. This has been evident in the improvement of steel qualities achieved over the last decade through the close cooperation between steel producers and the automotive sector.

However, if markets are fragmented, timescales are longer, risks are larger, and the relevance of technology spillovers is higher, there is a case for public funding to complement private investments. Innovation in low-carbon steel processes that also include CCS[18] is unlikely to be consumer-led, especially if the innovation does not improve the properties of the resulting steel. In addition, timeframes and investment volumes for demonstration are large, pointing to a more prominent role for public policy to guide and support the innovation process compared to classical product innovation. At the demonstration stage, there is a need for a sustained public funding of process innovation to transform ideas into industrial

17 For further details, see in the same issue Neuhoff, K., Acworth, W., et al. (2015), l.c.

18 Bassi, S., Boyd, R. et al. (2015): Bridging the Gap: improving the economic and policy framework for carbon capture and storage in the European Union. Grantham Institute for Climate Change and the Environment and the Centre for Climate Change Economics and Policy Brief June 2015.

reality. Technological progress should become the key criterion in determining the continuation of funding.

Once breakthrough technology options reach a commercial scale, investment in initial plants will still involve significant risks that extend beyond the plant exploiting the new technology to the entire firm. In the case of the steel sector, this is due to the central role of the blast furnace in integrated steelmaking. Firms are reluctant to bear such risks, in particular if low-risk alternatives exist in continuing the use of established technologies Therefore risk-sharing arrangements may be required. These should involve the public sector both with regard to the risks and the benefits. Future financing arrangements might consider the use of quasi-equity instruments, sharing both potential losses and profits from operations of initial commercial-scale facilities.

The adoption of new building practices and materials requires significant upfront investment to demonstrate the viability of new practices and the long-term viability of new materials. The extent to which initial investors will be able to capture the future benefits of the product must be explored in more detail, and if this leaves insufficient incentives, the existence and implementation of additional public support must be structured.

Institutional adjustments and additional regulatory instruments to facilitate implementation of sector roadmaps

Much of the emission reduction in the cement sector up until now was linked to adjustments to regulation for co-firing of waste, new permits to allow co-firing of biomass residue and adjustments to codes and standards for concrete and construction. Investment in innovative techniques and products depends on the confidence that such adjustment will be pursued in a timely manner. Hence an early analysis is necessary to assess whether and which precise adjustments are needed for the exploration and diffusion of further modernization options.

Regulation can help support the diffusion of economically viable options that are currently not being exploited due to inertia and other priorities in decision-making processes. This has been the prominent motivation for codes on thermal efficiency in buildings. Standards and regulation thus helped to facilitate the innovation and deployment of lower-carbon technologies. At the same time, regulation of the thermal performance of buildings limits the operational energy use in buildings, and could be complemented by labelling or standards to limit the volume of carbon embedded in the materials of the building. Or, to give another example, given the conservatism of the building and construction sector with respect to new low-carbon cements, there may be a role for public procurement for specific applications to gradually build up industry experience and provide demand for new cement types.

Potentially, norms and standards could be even more ambitious and prescribe activities that might not be economically viable to encourage innovation and cost reductions, as has been the case with fuel efficiency standards in the automotive industry. In the materials sector, this could involve requiring a certain thermal performance of a primary production process (irrespective of the origin of the materials).

A vision for low-carbon materials

The European production of materials must be highly energy efficient and innovative in a future that is shaped by ambitious climate and energy policy goals. It will therefore be important to develop a positive perspective towards carbon and energy improvements in materials production so as to attract investment and talent, increase efficiency, and remain among the technology leaders.

The 2030 framework for European climate and energy policies and sector-specific roadmaps for 2050 offer this sort of positive perspective, given that regulators develop the roadmap into a fitting policy framework. Materials are at the core of the low-carbon transition, and progress requires a dynamic industry that attracts young talent and delivers with less materials and increased value added. That way, the materials sector can not only contribute to environmental sustainability, but also to economic sustainability.

While there are significant opportunities to transition to low-carbon cement and steel sectors, there are also serious challenges and risks. It will therefore require both effective policy and forward-thinking, innovative companies to translate any such roadmaps into tangible investments and innovation.

Markets create economic opportunities and are therefore an important way of generating efficiencies if combined with carbon pricing for dealing with an externality. The analysis of steel and cement points to the importance of an effective carbon price signal both to producers and consumers in realizing the different modernization and innovation potentials (Table).

However, the problems within the European Union's steel and cement sectors and of climate change in general are both structural and long-term.

Innovation and structural change involve the economics of transformation and the design of new production processes in which industry structure and the capacity for strategic investment are crucial. The capital intensity of materials production and the relatively homogenous nature of products impede the ability of the industry to advance new production processes on its own. This implies an unavoidable role for strategic investment led by public sector agents if the industry is to adapt to the demands of the future and a necessary input from manufacturing and process-engineering expertise, while still supplying indispensable materials as well as creating employment and value.

Finally, at the consumer end, questions of consumer choice in materials and resource efficiency emerge: for example, habits, routines, and shortsightedness introduce structural inefficiencies and may blunt the impact of market-based instruments. Hence dedicated policies to adjust regulation and facilitate coordination are required to create an enabling environment.

European climate policy involving a predictable long-term strategy embedded in the broader policy framework can thus provide a focal point for the modernization of the European carbon-intensive materials industry. The European Union covers a territory large enough to host and finance demonstration projects. Climate policy has a well-defined objective to provide clear guidance and visibility and it is based at its core on a shared climate policy objective that facilitates cooperation across the European Union member states and beyond.

Table

A policy package for low-carbon materials

		CO_2 price to producers	CO_2 price to consumers	Innovation funding	Other regulation
Energy efficiency	Best available technology	X			
	Operational practices	X			
Carbon efficiency	Fuel shifting	X			
	Innovative process	X	X	X	
Materials efficiency	Building practices		X	X	X
	Innovative materials		X	X	X
	Recycling				X

Source: Own illustration.

Carbon prices both to producers and consumers are an important part of the policy package.

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