EXECUTIVE SUMMARY

Overview

Industry accounts for approximately one-third of global final energy use and almost 40% of total energy-related CO_2 emissions. Over recent decades, industrial energy efficiency has improved and CO_2 intensity has declined substantially in many sectors. However, this progress has been more than offset by growing industrial production worldwide. As a result, total industrial energy consumption and CO_2 emissions have continued to rise. Projections of future energy use and emissions show that without decisive action, these trends will continue. This path is not sustainable. Making substantial cuts in industrial CO_2 emissions will require the widespread adoption of current best available technology (BAT), and the development and deployment of a range of new technologies. This technology transition is urgent; industrial emissions must peak in the coming decade if the worse impacts of climate change are to be avoided. Furthermore, such emissions reductions will only be possible if all the regions of the world contribute. Action in OECD countries alone, which represent 33% of current global industrial CO_2 emissions, will not be sufficient to make the necessary reductions. Industrial production will continue to grow most strongly in non-OECD countries so that by 2050, in the absence of any further action, they will account for 80% of global industrial CO_2 emissions.

Industry exhibits a number of characteristics that set it apart from other end-use sectors and these need to be taken into account when designing energy and climate policies for the sector. First, while significant energy efficiency potentials remain, they are smaller than in the building or transport sectors. Policies should therefore promote realistic levels of energy efficiency improvement and CO_2 abatement and ensure, where possible, flexibility in the way these can be achieved. Secondly, many industries compete in global or regional markets, and so the introduction of policies that impose a cost on CO_2 emissions in some regions, but not others, risks damaging competitiveness and may lead to carbon leakage – in other words, industries relocating to regions with lesser carbon restrictions. While there is little, if any, evidence of such effects to date, this may become a significant problem if CO_2 prices rise substantially in the future. Thirdly, many industrial sectors have the knowledge, technology access and financing possibilities to reduce their own CO_2 emissions if governments provide a stable policy framework that will create clear, predictable, long-term economic incentives for the use of new efficient and low-carbon technologies.

Given these considerations, a global system of emissions trading may eventually be a crucial policy instrument for promoting CO_2 abatement in industry. However, a worldwide carbon market is unlikely to emerge immediately and so, in the short- to medium-term, international agreements covering some of the main energy-intensive sectors might be a practical first step in stimulating the deployment of new technologies, while addressing concerns about competitiveness and carbon leakage. Meanwhile, national energy efficiency and CO_2 policies, including standards, incentives and regulatory reform (including the removal of energy price subsidies), which address specific sectors or particular barriers, will continue to be necessary. Gaining public acceptance for certain new technologies may also be important to their widespread deployment.

To complement policies that generate market pull, many new technologies will need government support while in the research, development and demonstration (RD&D) phases before they become commercially viable. There is an urgent need for a major acceleration of RD&D in breakthrough technologies that have the potential to significantly change industrial energy use or greenhouse gas (GHG) emissions. Support for demonstration projects will be particularly important. This will require greater international collaboration and will need to include mechanisms to facilitate the transfer and deployment of low-carbon technologies in developing countries.

Technologies for the next industrial revolution

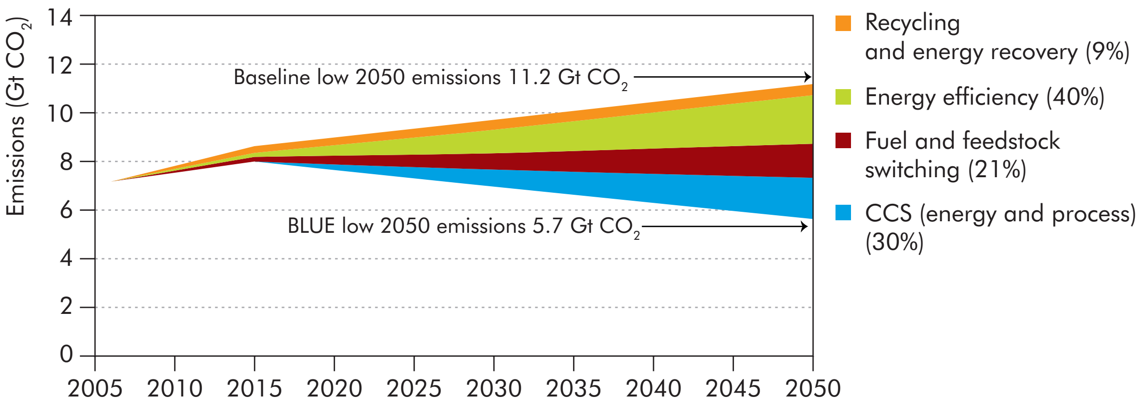
The introduction of current and new technologies can deliver significant reductions in CO_2 emissions from industry. In the BLUE scenarios, in which global energy-related CO_2 emissions are halved from current levels by 2050, direct CO_2 emissions in industry fall by 21% compared with today. In 2050 this represents a CO_2 reduction from Baseline scenario emissions of 7.5 Gt to 8.5 Gt. This reduction exceeds total present CO_2 emissions of North America. Because of different rates of industrial growth in the future, not all regions of the world will be able to cut industrial emissions by the same amount. This study indicates that emissions in OECD countries will need to fall by between 50% and 61% compared to today's level, whereas in China and the economies in transition reductions of between 31% and 34% will be necessary. In other emerging economies emissions grow between 19% and 90%, as this is where future growth in production is expected to rise the fastest.

The majority of the technological options to reduce industrial CO_2 emissions will cost between USD 50 and USD 100 per tonne CO_2, but some options with a cost of up to USD 200 per tonne CO_2 will be needed. Deploying these technologies will require increased investments. Global investments in industry under the BLUE scenarios are 20% higher than in the Baseline scenarios, an increase of between USD 2 trillion and USD 2.5 trillion between now and 2050. This is only around 6% of the total investment cost needed across all sectors to halve global CO_2 emissions.

The implementation of current BAT could reduce industrial energy use by up to between 20% and 30% and should be a priority in the short-term. But this will be nowhere near enough to achieve absolute reductions in CO_2 emission levels, as production is expected to double or triple in many sectors. Continued improvements in energy efficiency offer the largest and least expensive way of achieving CO_2 savings over the period to 2050 (Figure ES.1). Energy efficiency gains will need to increase to 1.3% per year, double the rate seen in the Baseline scenarios. This will require the development of new energy-efficient technologies. New low-carbon fuels and technologies will also be needed, with a smaller but important contribution from increased recycling and energy recovery. The use of biomass and electricity as CO_2-free energy carriers will be significant. While the technologies required are often sector-specific, the development and deployment of carbon capture and storage (CCS) will be critical for achieving deep emissions reductions, particularly in the iron and steel and cement sectors. The options outlined in this publication will not be sufficient to maintain significant CO_2 reduction into the second half of this century and new carbon-free production processes will have to be developed and deployed.

Technology development is fraught with uncertainties. Some of the technologies identified may never come to fruition, but future research may also deliver new technologies or breakthroughs that are not currently foreseen. A portfolio approach can help to deal with this uncertainty.

Figure ES.1 ▶ Technologies for reducing direct CO_2 emissions from industry, 2006 to 2050



Key point

Direct emissions in industry can be significantly reduced through a combination of energy efficiency, fuel and feedstock switching, recycling and energy recovery, and CCS.

Sectoral results

CO_2 emissions reductions will be needed across the whole of industry. But action is particularly crucial in the five most energy-intensive sectors: iron and steel, cement, chemicals and petrochemicals, pulp and paper, and aluminium. Together, these sectors currently account for 75% of total direct CO_2 emissions from industry, with contributions as follows: iron and steel 29%, cement 25%, chemicals and petrochemicals 17%, pulp and paper 3% and aluminium 1%.

Iron and steel

The global deployment of current best available technologies (BAT) could deliver energy savings of about 20% of today's consumption. Given the limited efficiency potential inherent in existing technologies, new technologies such as smelt reduction will be needed. Fuel switching can also help to reduce emissions. A switch from blast furnaces to gas-based direct reduced iron (DRI) could halve emissions, depending on the availability of cheap stranded gas. Biomass (charcoal), plastic waste and CO_2-free electricity also offer interesting opportunities. CCS is an important option that would allow the sector to achieve deep reductions in emissions in the future. Large-scale CO_2 capture pilot projects at iron and steel plants must be urgently developed in order to better understand the cost and performance of different CO_2 capture methods.

Cement

Reducing CO_2 emissions in the cement sector is very challenging owing to high process emissions related to the production of clinker, the main component in cement. Process CO_2 emissions alone are equal to approximately 1.2 Gt per year. Improving energy efficiency at existing plants, investing in BAT for new plants, and increasing the use of alternative fuels and clinker substitutes could reduce current energy use by 21%, but this will not be enough to achieve net emissions reductions in the future. New technologies should be developed and implemented, particularly in the application of CCS to cement production. CCS can reduce emissions in the sector by up to 1.0 Gt CO_2 in 2050. Urgent action is needed to support the development and demonstration of CCS for cement production. In the very long-term, new CO_2-free processes will need to be developed.

Chemicals and petrochemicals

The full application of best practice technologies (BPT) in chemical processes could achieve energy savings of 5.2 EJ/year or approximately 15%. Additional measures such as process intensification and process integration, the greater use of combined heat and power (CHP), and life-cycle optimisation by recycling and energy recovery from post-consumer plastic waste could save an additional 5 EJ of final energy. However, there are important barriers which constrain the exploitation of this theoretical potential. To achieve future CO_2 emissions reductions in the sector, a range of new technologies must be developed and successfully applied. These include novel olefin production processes such as the wider use of catalysis, membranes and other new separation processes, process intensification, and the development of bio-based chemicals and plastics. In addition, CCS for ammonia, ethylene and large-scale CHP applications will need to be developed. A life-cycle approach can be especially valuable in this sector as most carbon is stored in products.

Pulp and paper

Significant potentials exist in many countries to increase energy efficiency and reduce CO_2 emissions in the pulp and paper sector. A transition to current BAT could save up to 25% of energy used today. Reducing emissions in the sector will require additional improvements in efficiency, fuel switching to biomass, and the increased use of CHP. Promising new technologies such as black liquor gasification, lignin removal, biomass gasification and CCS will also be needed to achieve significant emissions reductions.

Aluminium

Most of the energy consumed in the aluminium industry is in the form of electricity used for smelting. The impact of implementing BAT is limited, offering the potential to reduce energy use by up to 12% compared with current levels. Important options include reducing heat losses in refineries and improving process controls, and reducing heat losses and the electricity used in smelters. In the longer-term, moving towards the use of zero-carbon electricity in smelters is the single largest opportunity for long-term CO_2 emissions reduction. New technologies such as wetted cathodes and inert anodes or carbothermic reduction also offer reduction opportunities, if they can be successfully commercialised.

Cross-cutting options

There are important cross-cutting technologies and options for reducing CO_2 emissions from a range of sectors, of which fuel switching to biomass and CCS are the two most significant and thus deserve particular attention for technology development. Other options include efficient motor and steam systems, CHP, and increased use of recycled materials.

Fuel switching, particularly to make greater use of biomass and biomass waste, offers significant opportunities for CO_2 emissions reductions in industry. However, iron and steel, pulp and paper, cement and chemicals will have to compete with the power, building and transport sectors for limited biomass resources. Such competition will put significant pressure on the price of biomass and could create economic barriers that could limit its potential use in industry. The development and use of high-yield crops, water management, soil management and land-use policies, together with an effective assessment of ecological sustainability, all need to be taken into account and closely co-ordinated to ensure the sustainability of biomass use.

Carbon capture technologies will need to be developed and implemented widely across different industrial sectors to realise their full emissions reduction potential. Approximately 30% of industry's CO_2 reductions in the BLUE scenarios are attributable to CCS. Significant investments are needed to support the development and demonstration of CCS in iron and steel, cement, ammonia and pulp and paper production. Major financial, economic, legal and regulatory barriers will have to be overcome before CCS can be widely deployed. Governments need to take a leading role in overcoming these barriers, particularly in relation to CO_2 transportation and storage, but industry should also begin to ramp up investments in CO_2-capture technologies and pilot projects. Large-scale demonstration of capture technology in industry is urgently needed and should be undertaken simultaneously with the demonstration projects planned for the power sector. CO_2 infrastructure and storage issues need to be considered, and this will perhaps result in synergies with the power sector.

Impacts on the demand for materials

The transformation of the global energy economy that is needed to achieve significant CO_2 reductions will have mixed impacts on the demand for materials. The effect on the overall demand for most major commodities will be small, although constraints on the availability of certain specialty materials could reduce the penetration levels of some low-carbon technologies. High levels of recycling will be required to keep up with material input requirements, particularly in transport. Decarbonisation of the power sector will require large increases in material inputs, but the overall impact on global demand for major commodities will be limited as the current share of total material use in the power sector is relatively small. A transition to low-carbon transport technologies, especially in the case of electric vehicles, could deplete known lithium resources. In the building sector, only a modest increase in the most important building materials will be required.

Implementing the technology transition

Achieving significant CO_2 reductions in industry will require both a step change in policy implementation by governments and unprecedented investment in best practice and new technologies by industry. A prerequisite for such actions is a clear understanding of the current energy and CO_2 emissions performance of industry. While the IEA indicator analysis presented in this report can help provide much of the information that is required, it is currently hampered by a combination of methodological difficulties and a lack of detailed and accurate data for some industries and countries. Private-sector led initiatives have started to address some of the gaps through the development of common methodologies and joint data gathering. However, further international cooperative efforts involving both governments and industry are needed to gather comprehensive and reliable industry-level energy and emissions data. International standards could play an important role in such an endeavour.

Roadmaps that show what is needed to take technologies from their current status through to full commercialisation are a further useful tool to help governments and the private sector take the right action. These roadmaps should include all the technical, policy, legal, financial, market and organisational requirements that are necessary to deliver an earlier uptake of more efficient and low carbon technologies into the market. For example, the International Energy Agency is collaborating with the World Business Council for Sustainable Development (WBCSD) and its Cement Sustainability Initiative to develop an international roadmap for the cement sector. This approach should be considered for other industrial sectors as well.