CLIMATE
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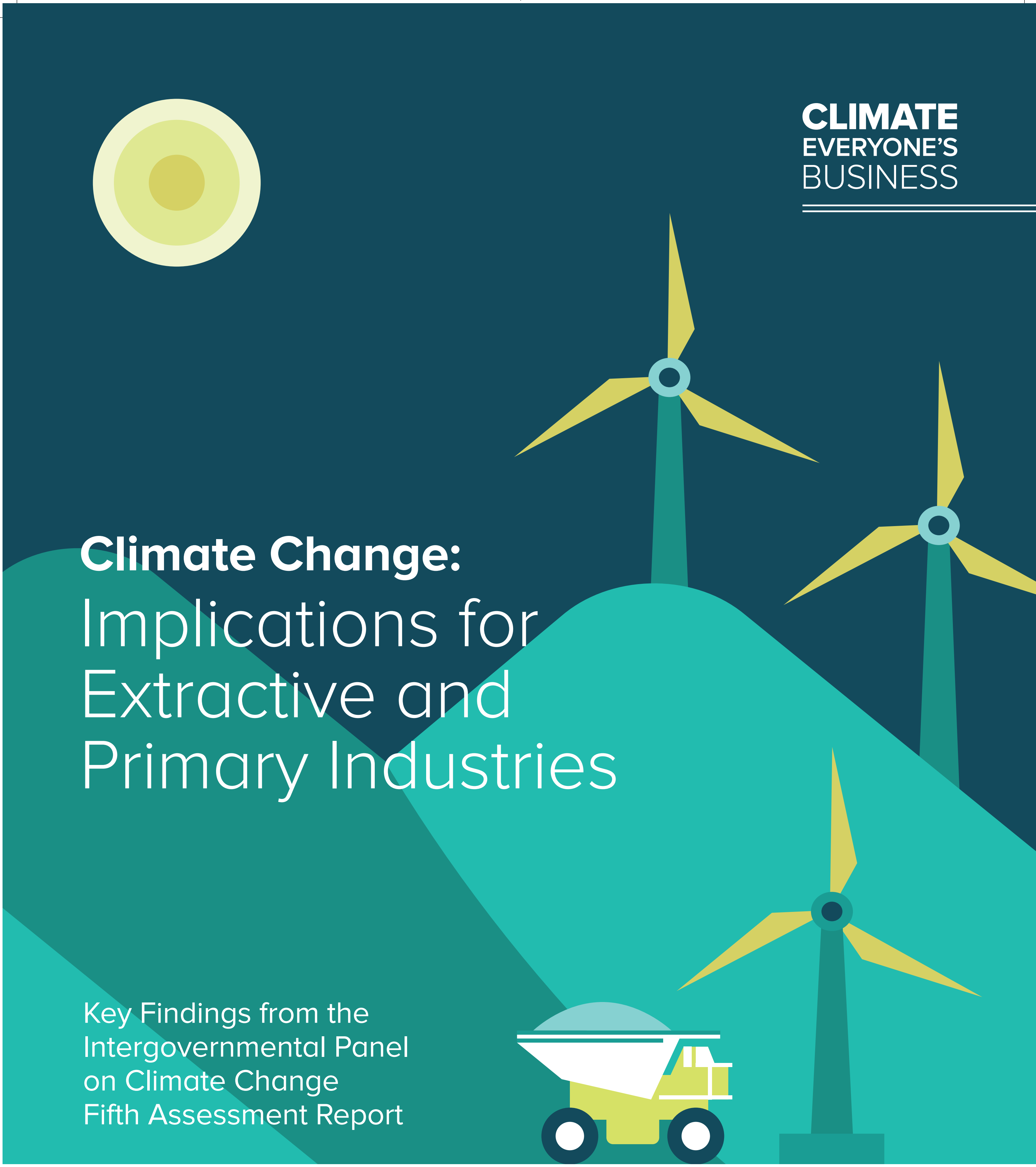
BUSINESS

Climate Change:
Implications for Extractive and Primary Industries



Key Findings from the Intergovernmental Panel on Climate Change Fifth Assessment Report

UNIVERSITY OF CAMBRIDGE
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The **Physical Science** of Climate Change

Rising temperatures:

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) concludes that climate change is unequivocal, and that human activities, particularly emissions of carbon dioxide, are very likely to be the dominant cause. Changes are observed in all geographical regions: the atmosphere and oceans are warming, the extent and volume of snow and ice are diminishing, sea levels are rising and weather patterns are changing.

Projections:

Computer models of the climate used by the IPCC indicate that changes will continue under a range of possible greenhouse gas emission scenarios over the 21st century. If emissions continue to rise at the current rate, impacts by the end of this century are projected to include a global average temperature 2.6–4.8 degrees Celsius (°C) higher than present, and sea levels 0.45–0.82 metres higher than present.

To prevent the most severe impacts of climate change, parties to the UN Framework Convention on Climate Change (UNFCCC) agreed a target of keeping the rise in average global temperature since pre-industrial times below 2°C, and to consider lowering the target to 1.5°C in the near future.

The first instalment of AR5 in 2013 (Working Group I on the physical science basis of climate change) concluded that by 2011, we had already emitted about two-thirds of the maximum cumulative amount of carbon dioxide that we can emit if we are to have a better than two-thirds chance of meeting the 2°C target.

Impact of past emissions:

Even if emissions are stopped immediately, temperatures will remain elevated for centuries due to the effect of greenhouse gases from past human emissions already present in the atmosphere. Limiting temperature rise will require substantial and sustained reductions of greenhouse gas emissions.

About this document

The Fifth Assessment Report from the Intergovernmental Panel on Climate Change is the most comprehensive and relevant analysis of our changing climate. It provides the scientific fact base that will be used around the world to formulate climate policies in the coming years.

This document is one of a series synthesizing the most pertinent findings of AR5 for specific economic and business sectors. It was born of the belief that the extractive and primary industries sector could make more use of AR5, which is long and highly technical, if it were distilled into an accurate, accessible, timely, relevant and readable summary.

Although the information presented here is a 'translation' of the key content relevant to this sector from AR5, the summary report adheres to the rigorous scientific basis of the original source material.

Grateful thanks are extended to all reviewers from both the science and business communities for their time, effort and invaluable feedback on this document.

The basis for information presented in this overview report can be found in the fully-referenced and peer-reviewed IPCC technical and scientific background reports at: **www.ipcc.ch**

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FOR MORE INFORMATION:
E-mail: AR5@europeanclimate.org
www.cisl.cam.ac.uk/ipcc
www.bsr.org
www.europeanclimate.org

AUTHOR:
France Bourgouin

REVIEWERS:
Cambridge Project Team:
Nicolette Bartlett
Stacy Gilfillan
David Reiner
Eliot Whittington

PROJECT DIRECTOR:
Tim Nuthall

PROJECT MANAGER/EDITOR:
Joanna Benn

EDITORIAL CONSULTANTS:
Carolyn Symon, Richard Black

PROJECT ASSISTANTS:
Myriam Castanié
Simon McKeagney

LAYOUT DESIGN:
Lucie Basset, Burnthebook

INFOGRAPHICS:
Carl De Torres Graphic Design

Key Findings

1 **Impacts of climate change on primary industries are wide ranging.** Physical impacts are likely to include damage to infrastructure and industrial capital assets, and could reduce availability of renewable natural resources including water.

2 **Total greenhouse gas (GHG) emissions from industry almost doubled between 1970 and 2010.** This reflects the steady growth in world production trends for extractive mineral industries and primary industries, despite their declining share of global GDP (gross domestic product).

3 **Most sector scenarios project that global demand for industrial products will increase by 45–60% by 2050 relative to 2010 production levels.** Rising demand for products used to reduce GHG emissions (e.g. insulation materials for buildings) and to adapt to climate impacts (e.g. materials for flood protection) could, perversely, create pressures to increase industrial emissions.

4 **An absolute reduction in GHG emissions by primary industry will require implementation of a broad range of mitigation strategies.** Opportunities for mitigation include both production-related strategies, geared towards improving industrial process efficiencies, and demand-related strategies focused on reducing the overall use of product material.

Executive Summary

Climate change will affect many aspects of exploration, extraction, and production of industrial commodities. It presents significant risks to primary industries. Extreme weather events such as high temperatures, droughts, floods, and wildfires are likely to decrease both the security of the energy supply and the reliability of industrial and transport infrastructure. Primary industries may also be affected by the reduced availability and accessibility of natural resources necessary for production.

Direct and indirect industry-related GHG emissions grew from the equivalent of 10.4 gigatonnes of carbon dioxide ($GtCO_2eq$) in 1990 to 15.5 $GtCO_2eq$ in 2010, reflecting the steady growth in world production trends for extractive industries, manufacturing and services. However, much attention is currently focused on ways of improving energy efficiency within the primary industry sector. Energy intensity could be reduced by up to 25% through wide-scale deployment of the best available technologies. Additional reductions in energy intensity of up to 20% could be realised through innovation, before technological limits are reached.

While mitigation measures often require an additional investment, they are also associated with enhanced competitiveness, reductions in running costs, new business opportunities, better environmental compliance, improved work conditions and reduced waste. They also present opportunities to improve innovation in industrial processes and stimulate investment in more efficient production techniques. Measures that facilitate cross-sectoral collaboration within and across industries, such as eco-industrial parks and regional eco-industrial networks, can help primary industry sectors to optimise material and energy use.

A broader societal shift from fossil fuels to renewable energy sources will also increase demand for certain industrial products and materials, in turn increasing energy use associated with making those products, and thus energy-related GHG emissions. As a consequence, an absolute reduction in GHG emissions from the primary industry sectors will require implementation of a broad set of mitigation options both inside and outside the sector, including a shift to low-carbon electricity generation and radical product innovations.

This summary focuses on the industrial sectors that are at the front of supply chains, rely principally on the extraction or exploitation of natural resources, and are energy intensive in their industrial processes. They include mining, cement, iron and steel, chemicals, aluminium, and pulp & paper.

Impacts of Climate Change

Natural resource availability

An increase in climate-induced weather-related hazards (such as forest fires, flooding, and windstorms) may affect the viability of mining operations, depending on their geographic location. This could increase operating, transportation, and decommissioning costs. High precipitation levels and related floods and erosion, and temperature extremes, would particularly affect surface mining in some regions. Changing permafrost conditions in cold climates could also potentially increase accessibility of mineral resources. Changes in storage and handling of coal may be needed due to increasing moisture content.

Transport infrastructure

Sea-level rise may affect some transport infrastructure, and so present a risk to the production and transport of industrial materials. Commercial trade in raw materials such as mineral ore, and in commodity products such as aluminium, steel and chemicals, relies on road, rail, and sea transport. Paved roads may be adversely affected by heat stress, thawing permafrost in the high north, and increased precipitation and flooding. Rail beds and bridges are susceptible to increased precipitation, flooding and subsidence, sea-level rise, extreme weather events and the freeze-thaw cycle. Ice roads in Arctic regions will be usable for shorter seasons. Ports will also be affected by climate-related rises in sea level. Pipelines for the transport of oil and gas can be affected by impacts of climate change, from sea-level rise to bushfires caused by heat waves. The supply, transport and transmission of energy are all likely to be affected by changes in the frequency and intensity of extreme weather events.

Water security

Climate change is likely to reduce renewable surface water and groundwater resources significantly in most dry subtropical regions, exacerbating competition for water among sectors. In contrast, water resource availability could increase in some instances at high latitudes. Thermal power generation (which provides 80% of global electricity; its share is projected to remain high under most mitigation scenarios) will be affected as rising temperatures and humidity decrease the efficiency of thermal conversion. In many regions, the decreasing volume and rising temperature of water available for cooling will potentially lead to reduced power generation, operation at reduced capacity, and the temporary shutdown of power plants.

Labour

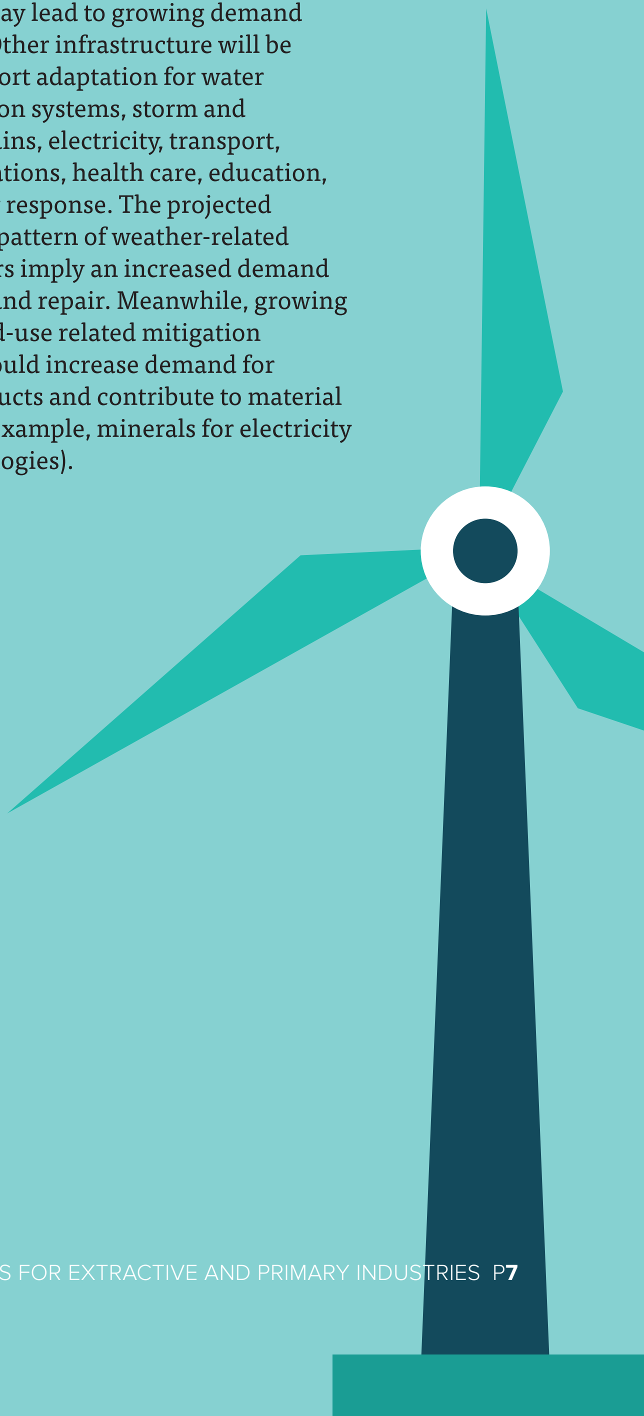
Falls in labour productivity are projected, particularly for manual labour in warm, humid climates. Productivity losses may be accentuated by increased incidence of malaria and other vector-borne diseases. Climate change can exacerbate drivers of conflict such as poverty and economic shocks, leading to instability in labour markets.

Resilience

A number of measures are available to help extractive and primary industries adapt to the impacts of climate change.

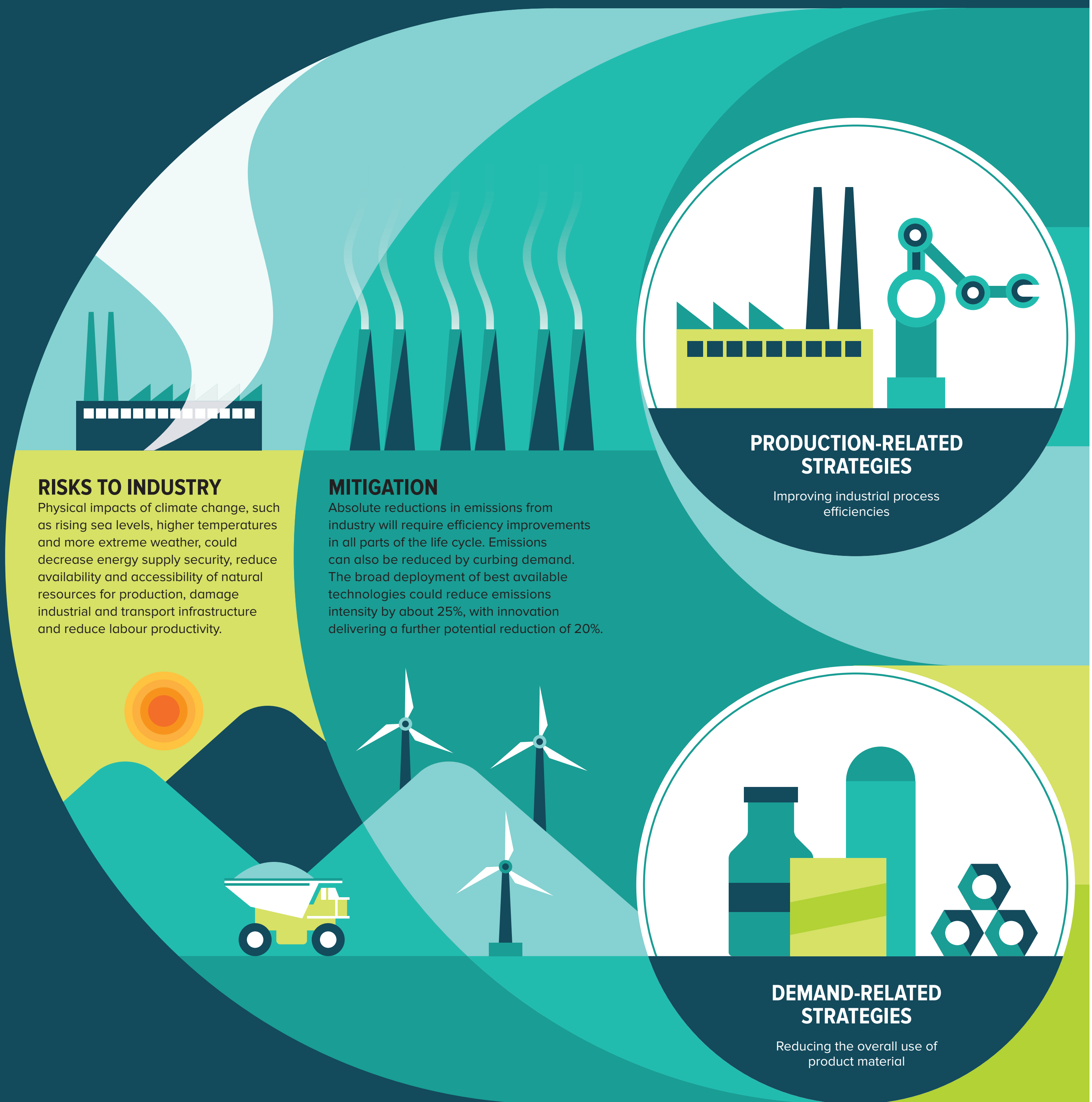
- **Adaptive water-management techniques,** including scenario planning, learning and evidence-based approaches, and flexible solutions, can address uncertainties.
- **Improving extraction methods and increasing recycling rates** can address the depletion of certain materials, including those used in mitigation technologies.
- **Technical and policy options for transport infrastructure** include upgraded design specifications for new construction, retrofitting structures, and modified land-use planning in coastal areas.
- **Efficient rationing of electricity** can reduce losses where power generation is a limiting factor and there is a risk to the reliability of supply.
- **Insurance** is linked to disaster risk reduction and climate-change adaptation because it enables recovery, reduces vulnerability and provides incentives for reducing risk.

Climate change adaptation options may require additional infrastructure investment, and thus increase the overall demand for materials such as cement and concrete. Improving flood defences in response to sea-level rise may lead to growing demand for materials. Other infrastructure will be needed to support adaptation for water supply, sanitation systems, storm and waste water drains, electricity, transport, telecommunications, health care, education, and emergency response. The projected changes in the pattern of weather-related natural disasters imply an increased demand for rebuilding and repair. Meanwhile, growing markets for end-use related mitigation technologies could increase demand for industrial products and contribute to material shortages (for example, minerals for electricity storage technologies).



Risks and Opportunities for Extractive and Primary Industries

Climate change is likely to affect many aspects of natural resource exploration and extraction, and the production of industrial commodities. Investments necessary for adaptation and mitigation measures are in many cases cost-effective.

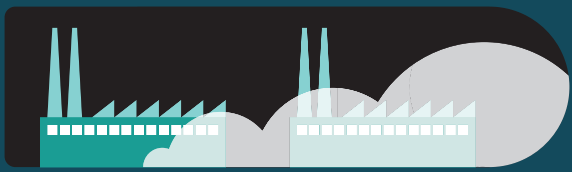


RISKS TO INDUSTRY

Physical impacts of climate change, such as rising sea levels, higher temperatures and more extreme weather, could decrease energy supply security, reduce availability and accessibility of natural resources for production, damage industrial and transport infrastructure and reduce labour productivity.

MITIGATION

Absolute reductions in emissions from industry will require efficiency improvements in all parts of the life cycle. Emissions can also be reduced by curbing demand. The broad deployment of best available technologies could reduce emissions intensity by about 25%, with innovation delivering a further potential reduction of 20%.



Greenhouse gas (GHG) emissions from industry almost doubled between 1970 and 2010. This reflects the steady growth in world production trends for extractive mineral industries and primary industries.

Primary industry accounts for around 30% of total global GHG emissions.

Most sector scenarios project that global demand for industrial products will increase by 45–60% by 2050 relative to 2010 production levels.

CASE STUDIES

EMISSION EFFICIENCY
Reduced emissions per unit of energy used

MINING
Switching from diesel-powered machinery to low-carbon energy sources is an important GHG mitigation strategy for this sector.

ENERGY EFFICIENCY
Improving the ratio of energy consumption to production of materials

CEMENT
Carbon dioxide (CO_2) savings of 40% have been reported on projects using ‘ultra high-strength’ concrete.

MATERIAL EFFICIENCY
Reducing the amount of raw material needed to create a product

CHEMICALS
In the Netherlands, material efficiency measures in plastics manufacture could halve emissions associated with plastic packaging.

PRODUCT-SERVICE EFFICIENCY
Using a product for longer and more intensively

METALS
Modular product designs within the aluminium sector allow longer product lives and so drive an overall reduction in demand for new material.

DEMAND REDUCTION
Reducing overall demand for new product materials, by changing consumption patterns

PULP AND PAPER
Reducing paper weight for newspaper and office use could cut paper demand by 37%. Increased recycling, printing on demand, removing print to re-use paper, and substitution by e-readers could also reduce demand.

Mitigation Potential

Primary industry accounts for around 30% of total global GHG emissions. Emissions include those from production of materials, manufacture of products from these materials, and services rendered through product use. Absolute reductions in emissions from industry will require efficiency improvements in all parts of the life cycle. Emissions can also be reduced by curbing demand, for example through more extensive and intensive use of products generated by these sectors. The broad deployment of best available technologies could reduce emissions intensity of these sectors by about 25%, with innovation delivering a further potential reduction of 20%, before technological limits are approached.

Mining

Energy consumption for mining and quarrying represents about 2.7% of worldwide industrial energy use. The energy requirements come largely from crushing and grinding and the use of diesel-powered machinery. Underground mining requires more energy than surface mining due to greater requirements for hauling, ore hoisting, ventilation, air refrigeration, water pumping etc. Energy consumption could be reduced by improving power management technologies and methodologies employed, such as underground water reticulation-based hydropower, more efficient mining equipment, and increased mining efficiencies before comminution. Improving the recovery ratio of valuable ore within the total of material extracted would increase material efficiency for the sector.

Mitigation strategies

Production-related strategies are mainly geared towards improving industrial process efficiencies. There are three main strategies.

- **Emission efficiency** Reducing the amount of emissions per unit of energy used, generally by switching to low-carbon energy sources.
- **Energy efficiency** Improving the ratio of energy consumption to production of materials.
- **Material efficiency** Reducing the amount of raw material needed to create a product. One-tenth of paper, a quarter of steel and half of all aluminium produced is scrapped (mainly in downstream manufacturing) and internally recycled.

Demand-related strategies are focussed on reducing the overall use of product material by changing the demand for industrial products. Strategies include increasing re-use and recycling, substitution with less energy- and GHG-intensive materials, and using materials more efficiently. There are two main strategies.

- **Product-service efficiency** Using products for longer and more intensively can help reduce the amount of product created.
- **Demand reduction** Reducing overall demand for new product, for example through re-use and recycling, will reduce emissions.

The energy intensity of the industry sector could be directly reduced by about 25% through the wide-scale upgrading, replacement and deployment of best available technologies, particularly in countries where these are not in use and in non-energy intensive industries.

Cement

Average CO_2 emission intensities for the cement sector have declined by 6% since 2005 and by 16% since 1990 in most regions. Fuel emissions account for about 40% of the sectoral total and can be reduced through improvements in energy efficiency and fuel switching for kilns, from coal to biomass waste. Emissions could be cut by universal adoption of best available technology and by increasing use of clinker substitutes by fly ash. CO_2 savings of 40% have been reported on projects using ‘ultra-high-strength’ concrete. Reducing demand for buildings and infrastructure can help reduce overall demand.

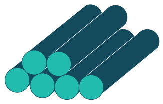
Iron and steel

Energy efficiency opportunities for the iron and steel sector include improved heat and energy recovery from process gases and waste streams, improved fuel delivery though coal injection, and improved furnace design and process controls. Iron-making emission efficiency benefits are possible through beneficiation of coal ash and iron ore, substitution of coal injection by cleaner fuel such as natural gas, waste plastics, biomass, or coal-based methane. Further advances come by shifting from blast furnaces and basic oxygen furnaces to gas-based direct reduced iron plants or electric arc furnaces. Mitigation potential can be significant: for example, in the Indian steel industry it is technically possible in the period 2010–2030 to reduce primary energy use by 87% compared to the primary energy used in 2007.

Ninety-one percent of the electricity savings and 64% of the fuel savings can be achieved cost-effectively (using an investment discount rate of 15%). Emissions can also be reduced by improving material efficiency, for example by eliminating the 26% of liquid steel lost to scrap. Demand for iron and steel can be reduced by improving end-use product-service efficiency.

Chemicals

Steam cracking for the production of light olefins, such as ethylene and propylene, consumes the most energy of any process in the chemical industry; upgrading all steam cracking plants to best practice technology could reduce energy intensity by 23%. A further 12% saving is feasible with best available technology. Emission efficiency improvements relate to the introduction of new nitrous oxide (N_2O) emission reduction technologies in nitric acid production, such as high-temperature catalytic N_2O decomposition, which has been shown to reduce N_2O emissions by up to 70–90%. This technology has been largely adopted in regions pursuing carbon emission reduction such as the EU and China, but it still offers large mitigation potential in Eastern Europe and the United States. In the Netherlands, increasing materials efficiency in plastics manufacture can halve emissions associated with plastic packaging.



Aluminium

Production of aluminium accounts for about 3.5% of global electricity consumption and about 3% of CO_2 emissions from industry. Eighty percent of the sector's GHG emissions stem from electricity use, making improving energy efficiency a priority mitigation strategy for this sector. The US aluminium industry consumes almost three times the theoretical minimum energy levels required, while the International Energy Agency estimates that the use of best available technology could reduce energy use by 10%. The yield in forming and fabrication of aluminium, from liquid aluminium to final product, is currently only 59%, which could be improved by process innovation and improving material efficiency. By closing supply chain loops and efficiently recycling materials locally, the requirement for global shipping of materials can be reduced (which also reduces supply chain vulnerabilities to climate impacts). Demand can be reduced by re-using aluminium building components such as window frames, curtain walls and cladding. Modular product designs allow longer product lives and an overall reduction in demand for new material.

Pulp and paper

Fuel and energy use in forestry, pulping and manufacturing are the sector's main sources of GHG emissions. Drying paper accounts for half of the energy used, which could be reduced by one-third using process improvements. The energy efficiency of pulp and paper mills can be increased by emerging technologies that use by-products of the chemical pulping process. The global pulp and paper industry generates about one-third of its energy from biomass (53% in the EU). Raising recycling rates by improving the design of easy-to-remove inks and adhesives can reduce energy intensity and CO_2 emissions over the total life cycle of paper production. Reducing paper weights for newspaper and office use could potentially cut paper demand by 37%. Demand can also be reduced through increased recycling (in 2011, recycling rates reached 70% in Europe and 67% in North America), printing on demand, the ability to remove print to re-use paper, and substitution of paper by e-readers.

Cross-sectoral collaboration

Activities within and across primary industries such as eco-industrial parks and regional eco-industrial networks can help businesses optimise material and energy use and enhance GHG mitigation. Such incentives reduce total consumption of virgin materials and final waste, and improve companies' efficiency and competitiveness. The geographic proximity of urban and industrial areas can lead to the use of urban refuse as a resource. The use of waste and industrial by-products as inputs to the cement industry can contribute emission reductions of up to 15–20%. Reuse and recycling of materials from urban infrastructure can reduce demand for primary products (e.g. ore) and so contribute to GHG mitigation. The grade of recycled material is often greater than that of ore.

Co-benefits

Primary industry sector mitigation measures are often associated with economic, social, environmental, and health-related co-benefits such as enhanced competitiveness, cost reductions, new business opportunities, better environmental compliance, better work conditions and reduced waste. Improving energy efficiency contributes to increased energy security, new business opportunities, increased competitiveness and productivity, and reduced health impact via reduced pollution and reduced waste. Policies that stimulate eco-innovation (e.g. through environmental regulation) and investment in efficient energy technologies can lead to higher employment.

Regional Perspectives

Greenhouse gas emissions from primary industry grew at an average annual rate of 3.5% annually between 2005 and 2010. In Asia, emissions rose by 7.0% annually, in the Middle East and Africa by 4.4%, and in Latin America by 2.0%. But they declined by 1.1% per year in OECD countries. In many countries, the rise in emissions was concentrated in the iron and steel, cement, pulp and paper, and aluminium sectors, while the share of mining and extractive industries has increased in the economies of many least-developed countries (LDCs).

Trade remains an important influence on production decisions and associated CO_2 emissions at a country level. Consumption-based emission inventories are higher in developed countries than production-based inventories as more industrial products are imported. The corollary is increased production-based inventories in industrial material-producing and exporting countries such as China.

Energy intensity has been reduced through technological improvements in developing countries such as China, India and Mexico, and in transition economies such as Azerbaijan and Ukraine. The potential for energy savings based on the widespread application of best available technologies is higher for developing countries (about 30–35%) than developed countries (about 15%). The ability of LDCs to improve GHG mitigation and emission efficiency depends on the success of policy implementation and regulation enforcement, the feasibility of adopting new energy efficient technologies, and the availability of alternative fuels.

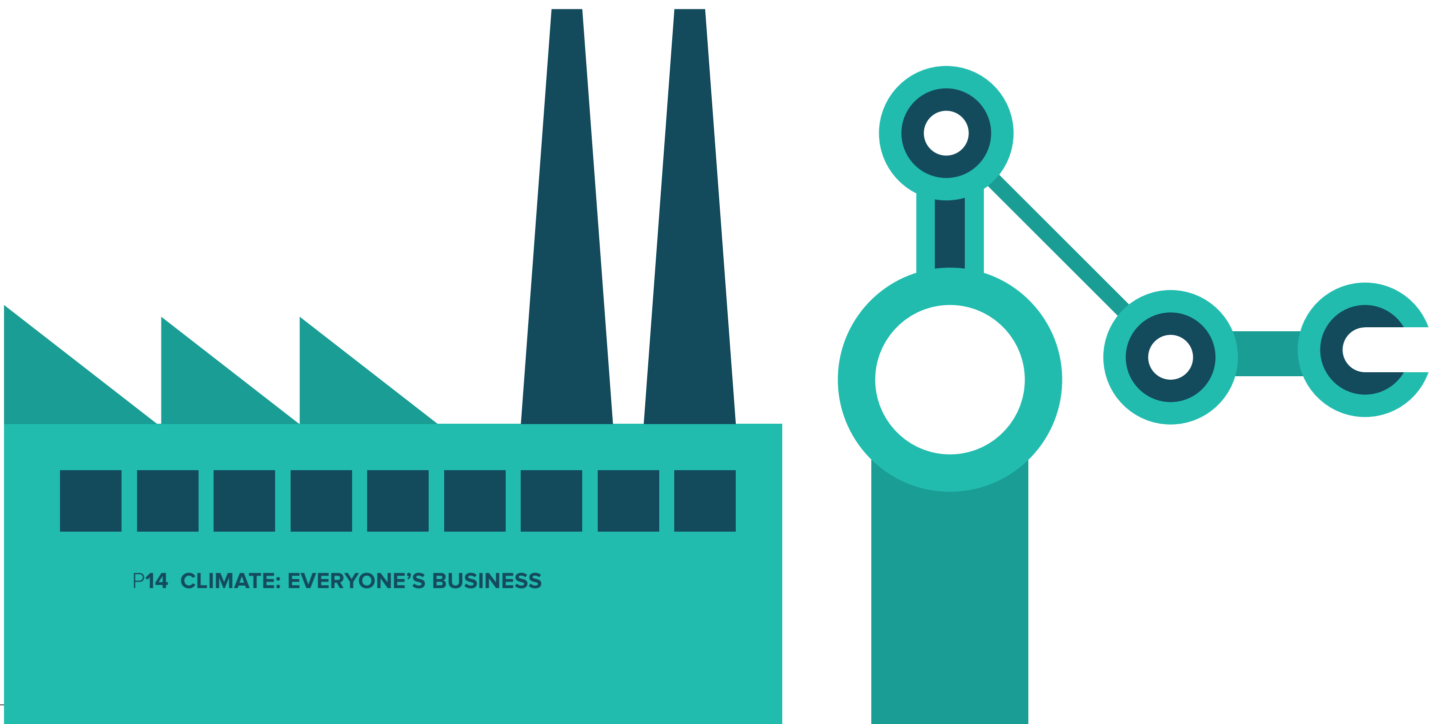
Investments necessary for adaptation and mitigation measures are in many cases cost-effective.

Conclusion

The decreasing availability and decreasingly reliable supply of raw materials, water, infrastructure, labour, and energy resulting from extreme weather events associated with climate change present significant risks to extractive and primary industries. However, companies and sectors can make themselves more resilient through measures such as increasing re-use and recycling, protecting infrastructure, improving energy efficiency and insurance.

Demand for products and materials from primary industries may either be positively or negatively affected by policies regarding climate change adaptation and mitigation. Measures such as improving flood defences, refurbishing damaged infrastructure or insulating buildings will increase demand, whereas re-use, recycling and product-service efficiency improvements will decrease demand, and could represent a commercial risk to unprepared businesses.

Despite these contradictory pressures, the overall demand for materials is expected to grow due to changes in population, income, age and lifestyle. Most sector scenarios suggest demand increases of 45–60% by 2050 relative to 2010 production levels. Against this backdrop, concerted policies that improve efficiency at each stage of the production chain will be needed to reduce industrial GHG emissions. Mitigation measures can provide opportunities for business to improve process efficiencies, stimulating investment in cross-sector collaboration initiatives and fostering innovation in production and product design. The investments necessary for adaptation and mitigation measures are in many cases cost-effective, and can be realised once barriers such as the lack of information and capacity are overcome.



Glossary

ADAPTATION

The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.

BASIC OXYGEN FURNACE STEELMAKING

A method of primary steelmaking in which carbon-rich molten pig iron is made into steel. Blowing oxygen through molten pig iron lowers the carbon content of the alloy and changes it into low-carbon steel.

BIOMASS WASTE

Waste of biological origin (plants or animal matter), excluding material embedded in geological formations and transformed to fossil fuels or peat.

CLIMATE CHANGE

Any significant change in climate that persists for an extended period, typically decades or longer.

CLIMATE IMPACT

The effects of climate change on natural and human systems.

CO-BENEFIT

The positive effect that a policy or measure aimed at one objective might have on other objectives.

COMMINUTION

The reduction of solid materials from one average particle size to a smaller average particle size, by crushing, grinding and other processes.

DIRECT REDUCED IRON

Produced from direct reduction of iron ore by a reducing gas produced from natural gas or coal.

ELECTRIC ARC FURNACE STEELMAKING

A steel-making process using an electrically powered furnace, capable of using (and thus recycling) steel scrap.

GREENHOUSE GAS

A gas in the atmosphere, of natural and human origin, that absorbs and emits thermal infrared radiation. Water vapour, carbon dioxide, nitrous oxide, methane and ozone are the main greenhouse gases in the Earth's atmosphere. Their net impact is to trap heat within the climate system.

MITIGATION

A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

PRIMARY INDUSTRY

For this briefing, defined as principally relying on the extraction of natural resources which are energy intensive such as mining, cement, iron, steel, chemicals, pulp, paper and non-ferrous metals.

PROJECTION

A potential future evolution of a quantity or set of quantities, often computed by a model. Projections involve assumptions that may or may not be realised, and are therefore subject to substantial uncertainty; they are not predictions.

RENEWABLE ENERGY

Any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use.

RESILIENCE

The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure.

TRANSITION ECONOMY

An economy that is changing from a centrally planned economy to a free market.

"Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."

IPCC, 2013

Disclaimer:

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The University of Cambridge Institute for Sustainability Leadership (CISL) brings together business, government and academia to find solutions to critical sustainability challenges.

Cambridge Judge Business School (CJBS) is in the business of transformation. Many of our academics are leaders in their field, creating new insight and applying the latest thinking to real-world issues.

BSR is a global nonprofit business network of more than 250 member companies. We develop sustainable business strategies and solutions through consulting, research, and cross-sector collaboration.

For more information:

E-mail: AR5@europeanclimate.org
www.cisl.cam.ac.uk/ipcc
www.bsr.org
www.europeanclimate.org