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Driving sustainable industrial innovation for global change

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- **ETP 2015 project**
- **Role of sustainable industrial innovation in the 2DS**
- **Measuring industrial innovation progress**
- **Drivers for industrial innovation**
- **Challenges for industrial innovation**
- **How to foster sustainable industrial innovation?**

- **Part 1: Global Energy Perspective**
 - ✓ 1.1 Global Outlook
 - ✓ 1.2 Tracking Clean Energy Progress (TCEP)
- **Part 2: Driving the Change**
 - ✓ 2.1 Innovation as a sustainable engine
 - ✓ 2.2 Renewables integration through technology and policy innovation
 - ✓ 2.3 Innovation of CCS
 - ✓ **2.4 Driving sustainable industrial innovation**
 - ✓ 2.5 Energy technology adoption, adaptation and development by non-member countries
 - ✓ 2.6 China's innovation, energy and climate nexus

Driving sustainable industrial innovation,

- **WHAT?** Explore its contribution in meeting climate targets through 2DS
- **WHY?** Analyse major existing barriers and drivers
- **HOW?** Explore opportunities and mechanisms for more effective progress

INDUSTRIAL PROCESS INNOVATION

Research, develop, demonstrate and deploy new processes and products that improve performance of an industrial activity

INDUSTRIAL PRODUCT INNOVATION

Research, develop, demonstrate and deploy new processes and products that reduce the environmental impact of an industrial activity

SUSTAINABLE INDUSTRIAL PROCESS INNOVATION

SUSTAINABLE INDUSTRIAL PRODUCT INNOVATION

- **Carbon capture application to existing processes**
- **Innovative processes, direct or indirect enablers of carbon capture:**
 - **Blast furnace with Top Gas Recycling**
 - **Upgraded Direct Reduced Iron process: Ulcored**
 - **Upgraded Smelting Reduction process: Hisarna**
 - **Use of hydrogen enriched reducing gas in Blast Furnace**
 - **Electrolysis reduction: Ulcowin/Ulcolysis**
- **Systemic approaches:**
 - **Valorisation of waste gases from existing processes, e.g. waste gas-to-ethanol.**
 - **High value-added products with enhanced characteristics**

- **Carbon capture in cement kilns**
 - **Post-combustion: solvent extraction, calcium looping or membrane processes.**
 - **Oxy-fuelling: partial or full**
- **Fluidised-bed advanced cement kiln system**
- **Low-carbon cements**
 - **Aether clinker**
 - **Calix**
 - **Celitement**
 - **Novacem**
 - **...**

- **Naphtha catalytic cracking for olefin production**
- **Methanol to Olefin route (MTO)**
- **Biomass use as feedstock**
 - **Biomass gasification → MTO**
 - **Biomass fermentation → dehydration**
- **Low-carbon hydrogen generation**
- **Enhanced membrane separation techniques**
- **Carbon capture applications to chemicals production**
- **Development of sustainable products: lighter organic materials, resource-efficient building materials, etc**

- **Black liquor gasification enabling generation of electricity, bio-chemicals and bio-refinery products**
- **Carbon capture applications**
- **Bio-products diversification, e.g. kraft market pulp mills producing dissolving pulp for the textile industry, etc**
- **Breakthrough concepts, e.g. production of pulp at low temperature and atmospheric pressure by using deep eutectic solvents**

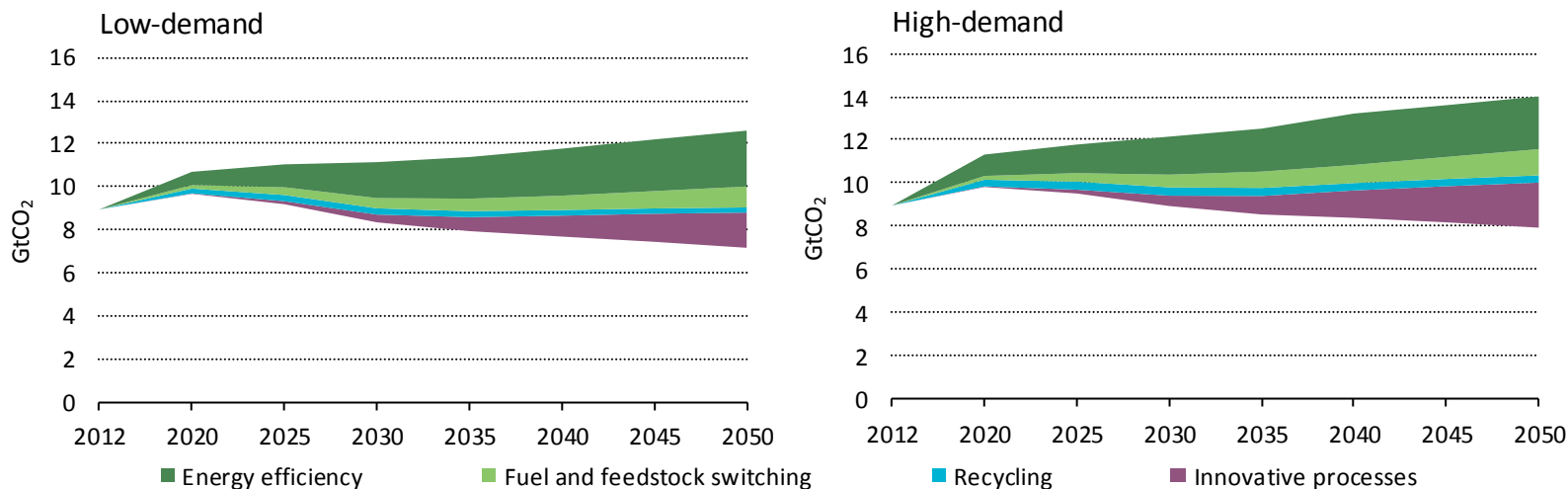
Aluminium sector

- Alternative processes to the Hall-Heroult widely used process
 - Direct carbothermic reduction of alumina
 - Kaolinite reduction
- Enhanced value-added products

Industrial sector

- Identification of processes that enable the use of non-fossil based and alternative feedstocks, as biomass and CO₂
- New business models that valorise energy and CO₂ savings, e.g. industrial excess heat recovery

Direct industrial CO₂ emission reductions between 6DS and 2DS by technology

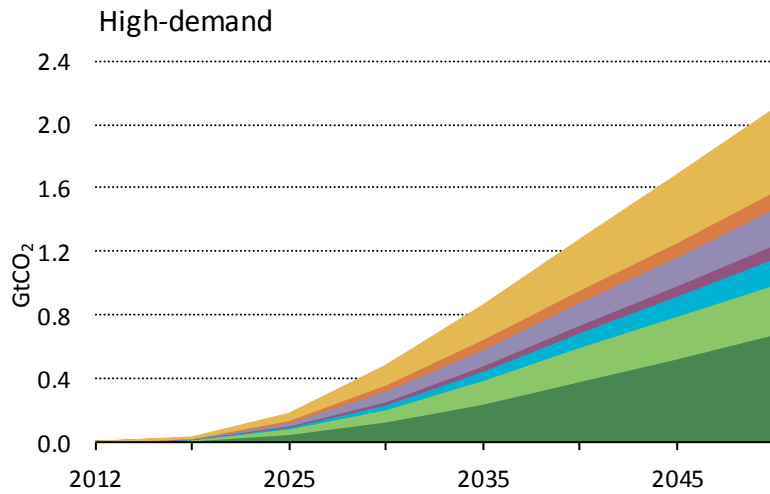
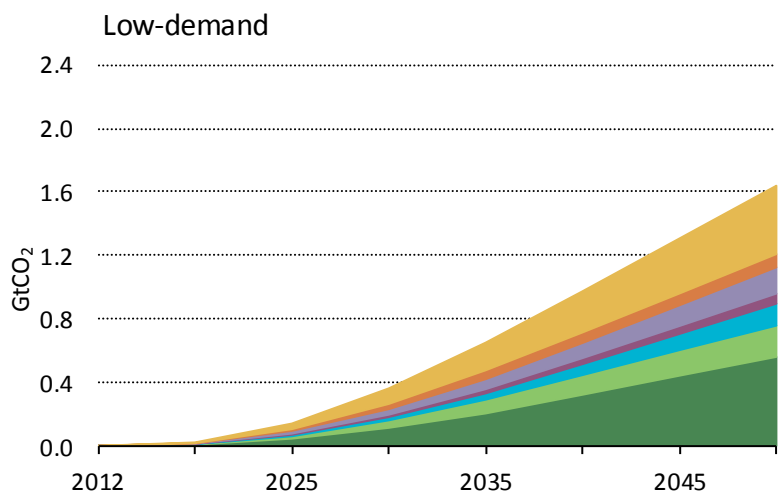


Note: Preliminary results, modelling cycle not completed. Innovative processes include CCS.
Source: IEA analysis.

JUST PRELIMINARY RESULTS

- Around 30% of direct CO₂ industrial emission reductions by 2050 in the 2DS hinge on processes that are not commercially available today.

Direct industrial CO₂ emission reductions between 6DS and 2DS from innovative processes



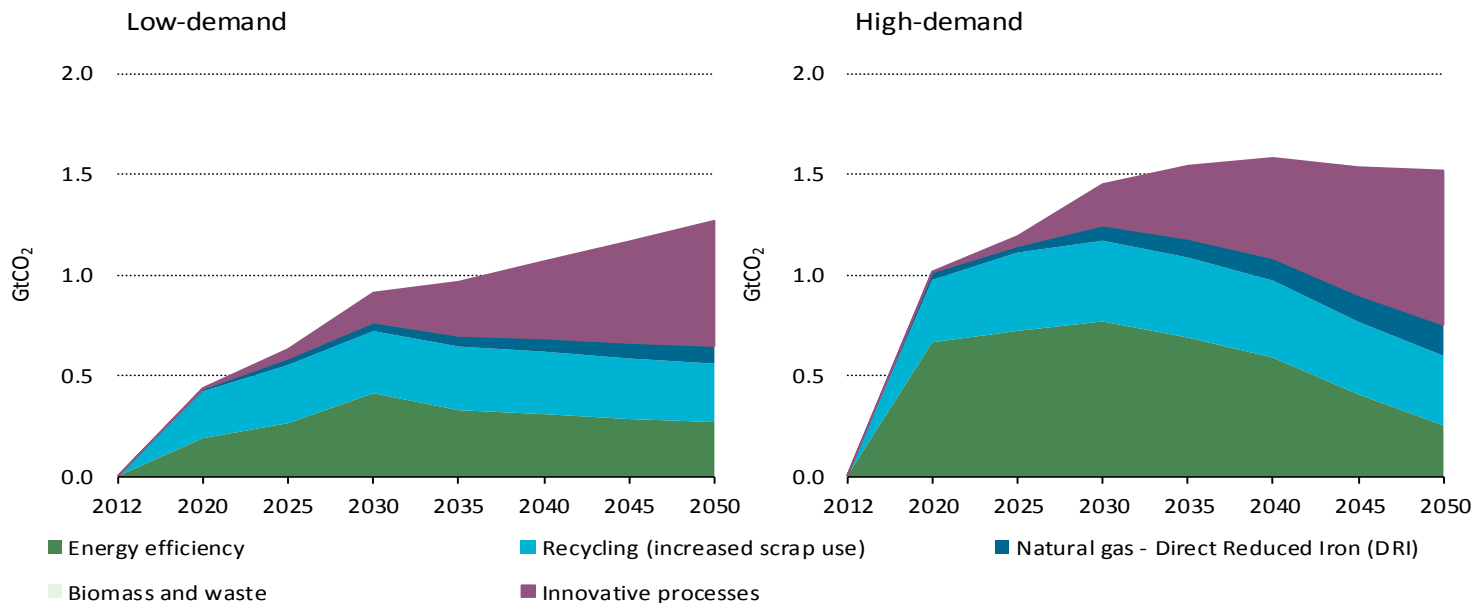
■ China ■ India ■ Other developing Asia ■ Non-OECD Latin America ■ Africa and Middle East ■ Economies in transition ■ OECD

Note: Preliminary results, modelling cycle not completed.
Source: IEA analysis.

JUST PRELIMINARY RESULTS

- **Non-OECD countries contribute with almost 75% of global industrial direct CO₂ emission reduction efforts through innovative processes in the 2DS.**

Global iron & steel direct CO₂ emission reductions between 6DS and 2DS by technology

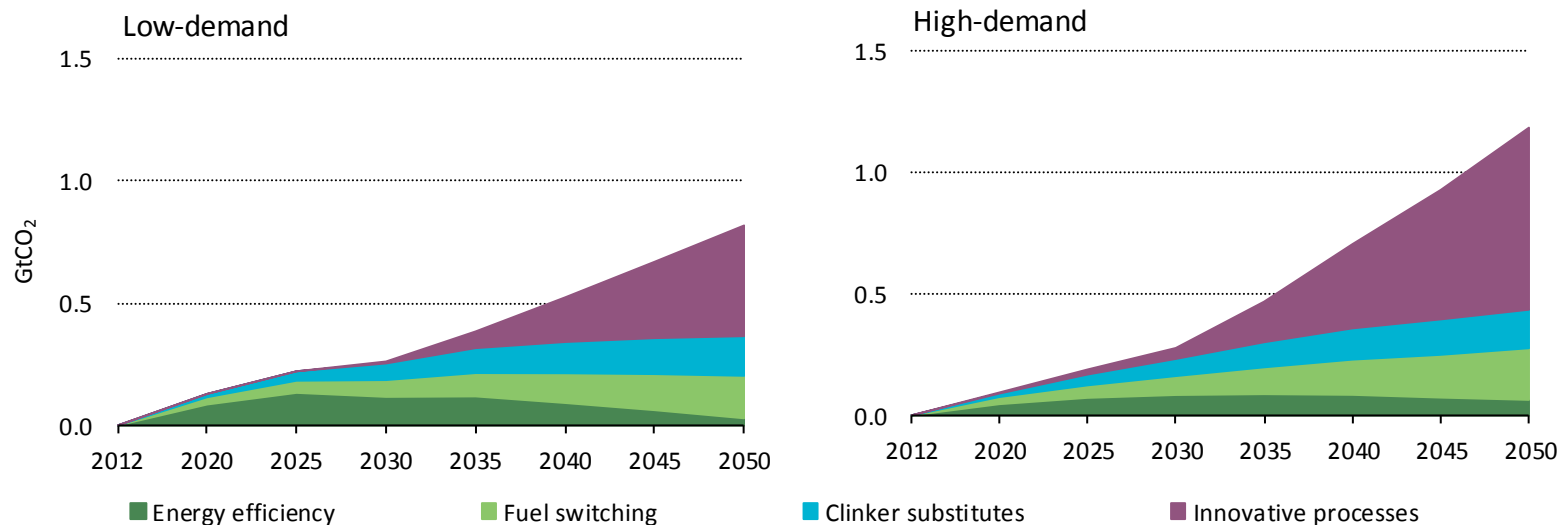


Note: Preliminary results, modelling cycle not completed. Innovative processes include CCS.
Source: IEA analysis.

JUST PRELIMINARY RESULTS

- About 50% of required direct CO₂ emission reductions in the iron & steel sector by 2050 in the 2DS hinges on innovative processes.

Global cement direct CO₂ emission reductions between 6DS and 2DS by technology



Note: Preliminary results, modelling cycle not completed. Innovative processes include CCS.
Source: IEA analysis.

JUST PRELIMINARY RESULTS

- Around 60% of required direct CO₂ emission reductions in the cement sector by 2050 in the 2DS hinges on innovative processes.

Typical indicators measure dedicated efforts (input-based):

- R&D investments
- R&D intensity (as a share of sales or business value-added)

And present significant limitations:

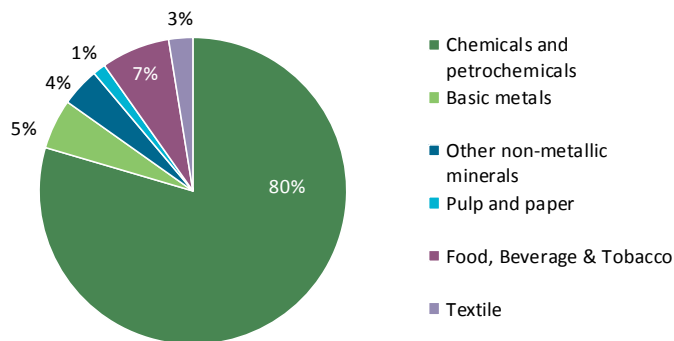
- Limited scope: demonstration and deployment missing
- Limited regional and time coverage
- Inadequacy to track industrial innovation effectiveness, no visibility on results
- Difficulty to segregate sustainable innovation progress from the broader industrial innovation

Need to build more detailed industry performance databases to develop output-based industrial innovation metrics,

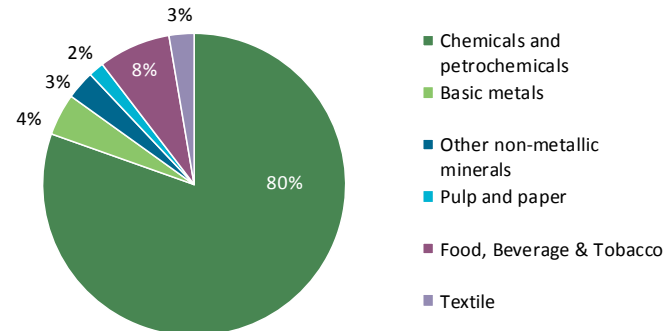
- Financial indicators:
 - Value-added generated from new processes/products
 - Value-added intensity as a share of RDD&D spending
- Sustainability indicators:
 - Energy/CO₂ emission savings related to new processes/products
 - Energy/CO₂ emission savings intensity per unit of monetary RDD&D spending

Business R&D spending in selected industrial sectors

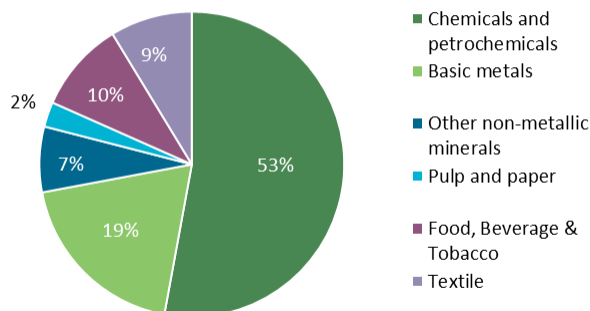
OECD, 2000: 62,340 million PPP USD



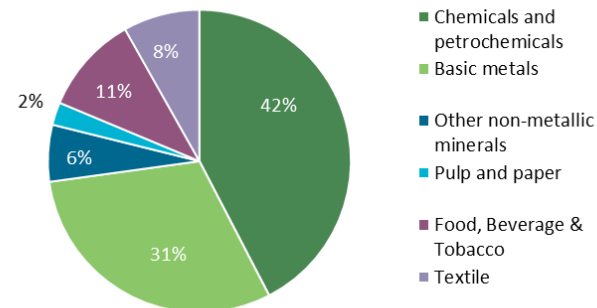
OECD, 2011: 138,503 million PPP USD



China, 2000: 6,102 million PPP USD



China, 2011: 55,764 million PPP USD

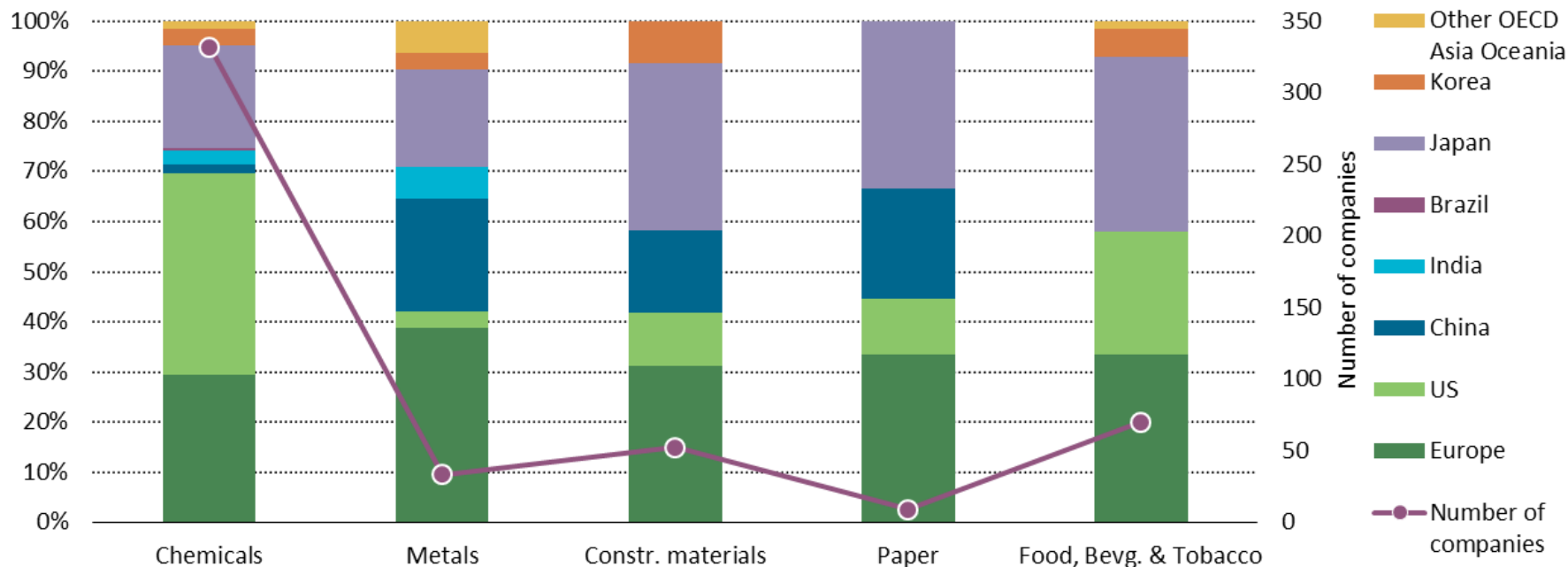


Note: OECD excludes New Zealand, Chile, Denmark, Estonia, Greece, Iceland, Ireland, Luxembourg, Sweden, Switzerland, UK due to lack of data. Due to data availability limitations in OECD Europe data series, Poland is only included in the period 2005-2011, Slovak Republic is only included in the period 2006-2011, France, Portugal is only included in the period 2007-2011, and Netherlands is only included in the period 2008-2011. OECD Asia Oceania data series, Israel is excluded in chemicals and petrochemicals, basic metals, other non-metallic minerals and pulp and paper sectors.

Source: The OECD Analytical BERD (ANBERD) database.

■ While OECD countries have maintained their industrial R&D spending pattern, China presents a more distributed pattern and a spending shift from the chemicals to the basic metals sector.

Industrial sectors role within top 2000 world companies by R&D spending in 2012

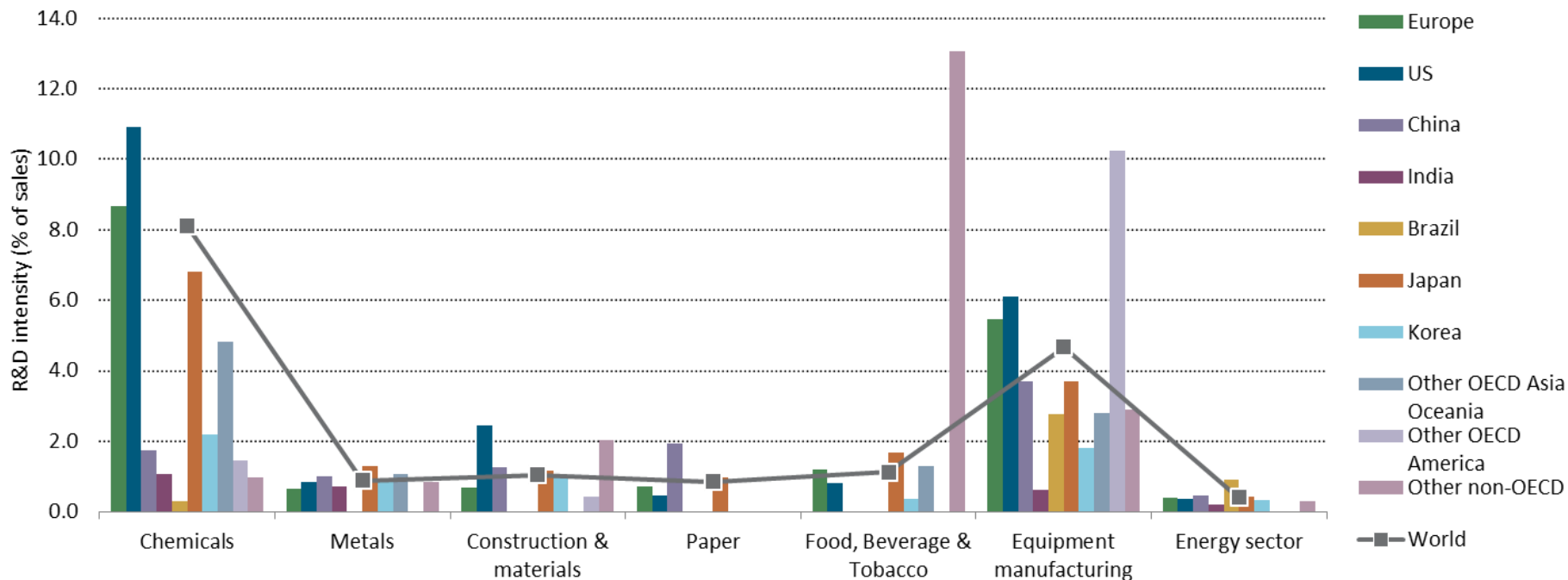


Note: The textile sector is embedded within the personal goods sector in the EC, 2013 database, thus textile companies are not included within the selected industrial sectors*.

Source: The 2013 EU Industrial R&D investment scoreboard, European Commission (EC, 2013).

- **25% of top 2000 companies are related to industrial sectors*, of which 67% belong to the chemicals sector.**
- **Almost 2/3 of the ranked industrial companies are located in EU and US.**

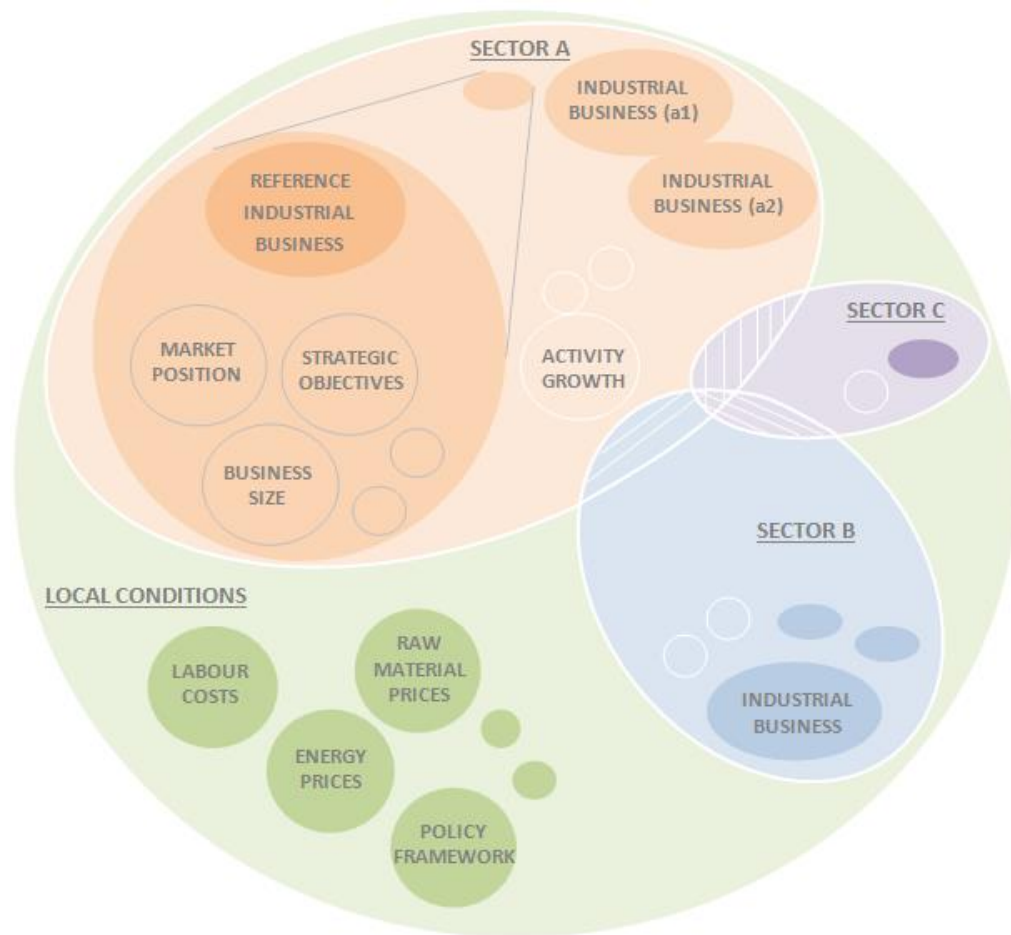
R&D intensity of top 2000 world companies by R&D spending in 2012



Note: The textile sector is embedded within the personal goods sector in the EC, 2013b database, thus textile companies are not included within the displayed sectors.

Source: The 2013 EU Industrial R&D investment scoreboard, European Commission (EC, 2013).

- Chemical companies spent five times more in R&D as a share of sales in average than businesses in other sectors.
- Equipment manufacturers had an R&D intensity twice as in other industrial sectors with the exception of the chemicals sector.



Are industrial innovation and sustainable industrial innovation driven by a different pattern of inner and outer factors?

Researched cases conclude that a unique driving pattern cannot be generalised and drivers have different impact at each innovation stage

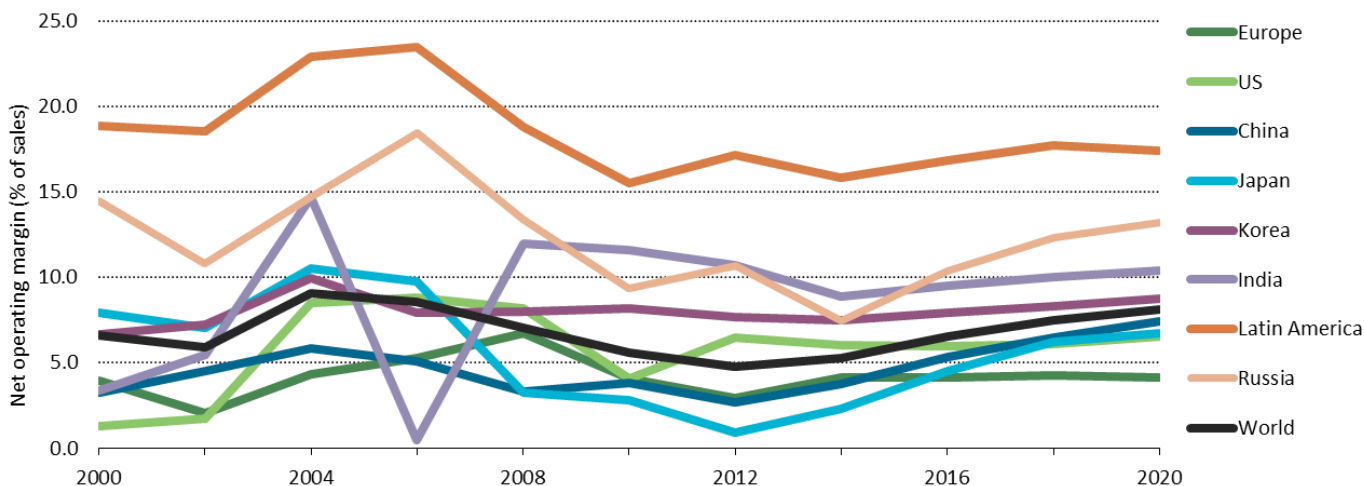
- Industrial innovation is driven by a complex interaction among inner and outer business factors

- Ever-changing economic and policy framework
- Investment risk management
- Balancing confidentiality and knowledge sharing
- Difficulty to penetrate a market dominated by a reduced number of technologies
- Other...

More specific challenges to sustainable industrial innovation,

- Potential need to develop new infrastructure (e.g. CO₂ transport and storage)
- Complexity to track environmental impacts along the product value chain
- Other...

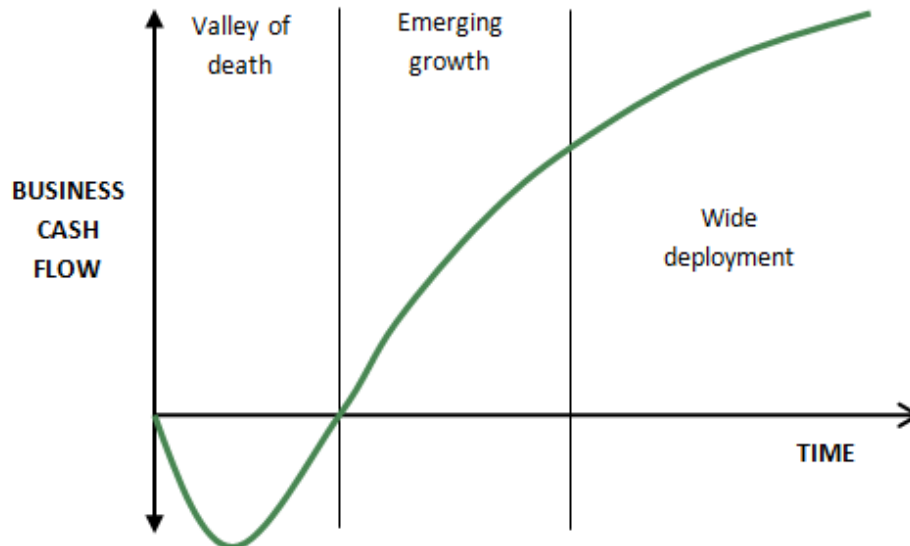
Net operating margin in the iron and steel sector by region



Note: Net operating margin values from 2014 onwards are estimates. China excludes Hong-Kong.
Source: IHS, 2014.

- Influencing factors: product demand, energy prices, feedstock quality and availability, labour and environmental compliance costs, tradability of a product, etc.
- Long-term visibility of industry outlook and its environment is key to define innovation investment strategies.

- Risk inherent factor of industrial innovation.
- Risk: Uncertainty intensity & Capital intensity
- Risk perception varies throughout the innovation process:
 - Research and development: greater uncertainty (concept or technology not proven yet) but typically lower capital intensity
 - Demonstration: moderate uncertainty (technology proven at small scale) but greater capital intensity



- **Widening collaborative frameworks and competition can accelerate innovation**
- **Associated challenges,**
 - **How to find the right balance?**
 - **Robust but flexible IP protection framework**
 - **Regional clustering or PPP may face some competitiveness limitations**
 - **Government structured nationally or regionally**
 - **Companies can be globally established**
- **Associated opportunities,**
 - **Investment risk sharing**
 - **Integrated solutions: cross-cutting scope, all stages of product value chain, private and public partnerships**

How to foster sustainable industrial innovation? (I) – Opportunities for action

- Design policy and market strategies that clearly valorise reduced environmental impacts of industrial activities with long-term visibility to prioritise sustainability benefits in industrial investment strategies.
- Design long-term low-carbon national/regional strategies that identify and prioritise breakthrough industrial technology and alternative product value chain options to meet sustainability targets.
- Promote cross-sectorial collaboration to identify opportunities to improve product life cycles sustainability.
- Encourage the collection of output-based sustainable industrial innovation metrics with a wide regional coverage to enable a robust evaluation of related investments effectiveness.

Design and implement adequate investment de-risking mechanisms linked to long-term low-carbon strategies,

- **Transparent selection criteria and reduced bureaucracy.**
- **Target innovation processes instead of innovation providers.**
- **Balancing a wide enough scope without losing effectiveness.**
- **Results-oriented dynamic mechanism to track and reward good performance throughout the innovation process.**
- **Maximise impact, e.g. technology transfer requirements**

Create cooperative innovation frameworks,

- Multi-sectorial partnership including public/private stakeholders along the product value chain.
- Clear objectives that reflect a long-term vision of partner's engagement.
- Broad international scope of engaged partners to maximise impact.
- Results-oriented mechanism that tracks the effectiveness of the partnership and progress on the different work streams.

- **Preliminary draft distributed for discussion on 13 October**
- **IEA Global Industry Experts Dialogue workshop on 23 October**
- **Expert feedback to preliminary draft submitted by 31 October**
- **Develop a revised chapter draft: workshop discussions/feedback**
- **Industry chapter external review - 24 Nov to 5 Dec**
- **ETP 2015 publication – April/May 2015**



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Thanks

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Questions for discussion?

1. Which are the key short and long-term challenges being faced by your sector?
2. How can industrial innovation help to solve these challenges?
3. What drives innovation investment decisions at the business level?
4. Which are the main factors preventing sustainable industrial innovation from advancing at a faster pace?
5. Which specific policy mechanisms would better contribute to advance sustainable industrial innovation?
6. Which mechanisms could reduce investment risks associated to industrial innovation activities?
7. How can cross-sectorial and international collaboration be more effectively pursued while keeping competitive advantage?
8. What role do you see public-private partnerships (PPPs) playing to advance sustainable industrial innovation?