INTERVIEW

THE INSTRUMENTAL ROLE OF INDUSTRY DECARBONIZATION IN IEA'S SUSTAINABLE DEVELOPMENT SCENARIO

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INTERNATIONAL ENERGY AGENCY

Founded in 1974, the **International Energy Agency** IEA was initially designed to help countries co-ordinate a collective response to major disruptions in the supply of oil, such as the crisis of 1973/4. While this remains a key aspect of its work, the IEA has evolved and expanded significantly.

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 30 member countries and beyond.

Today, the IEA is at the heart of global dialogue on energy, providing authoritative analysis through a wide range of publications, including the flagship World Energy Outlook and the IEA Market Reports; data and statistics, such as Key World Energy Statistics and the Monthly Oil Data Service; and a series of training and capacity building workshops, presentations, and resources. The four main areas of IEA focus are Energy Security, Economic Development, Environmental Awareness, Engagement Worldwide.

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SUMMARY

Industrial sectors play an important role in all efforts of reducing global greenhouse gas emissions. Energy efficiency, fuel switching, material use reductions and CCUS can contribute to curbing emissions from the sector sufficiently to bring the world in line with climate goals of the Paris agreement. Many industrial processes remain 'hard-to-abate' and the potential for electrification is limited by techno-economic barriers. Prerequisite for a successful transition is the interest and involvement of stakeholders of the financial community.

Q1. What is the role of industry decarbonization in climate action?

> *The contribution of industry to global energy-related CO2 end-use emissions lies at one third in 2018 and this share is expected to increase in IEA's Sustainable Development Scenario.*

Given its substantial contribution to emissions and its high energy intensity, the industry sector plays a key role in reaching global climate ambitions as stipulated in the Paris Agreement of 2015. The contribution of industry to global energy-related CO_2 end-use emissions lies at one third in 2018 and this share is expected to increase in IEA's Sustainable Development Scenario. While the power sector, buildings and road transport manage to deploy low-carbon technologies at scale, the industry sector has industrial processes where emissions remain costly or 'hard-to-abate'. Global emissions from the combustion of fossil fuels decline by around two third from 33 Gt today to below 10 Gt in 2050 in the Sustainable Development Scenario. In the industry sector, the decline of direct emissions is 50% relative to today, leaving 3 Gt CO_2 unabated in 2050. Process emissions related to industrial production (mostly cement calcination) decline by nearly 40% to around 1.4 Gt in 2050. The majority of the overall emissions savings (i.e. process and energy-related) are from the production of cement, iron and steel and petrochemicals; energy-intensive industries that together account for around two-thirds of total industry sector CO_2 emissions today.

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Q2. How do you expect emissions savings will be achieved?

The 2019 edition of the World Energy Outlook marks the first time where the IEA's Sustainable Development Scenario has key results extended to 2050 and a special effort was made to better understand the contribution of the sector to climate targets. Industry decarbonization requires a host of technologies and measures. There is no single or simple solution to reach these goals. Instead, a variety of technologies and policy measures need to be pushed to reach sustainability targets. The largest near-term options are in energy efficiency, material efficiency and fuel switching.

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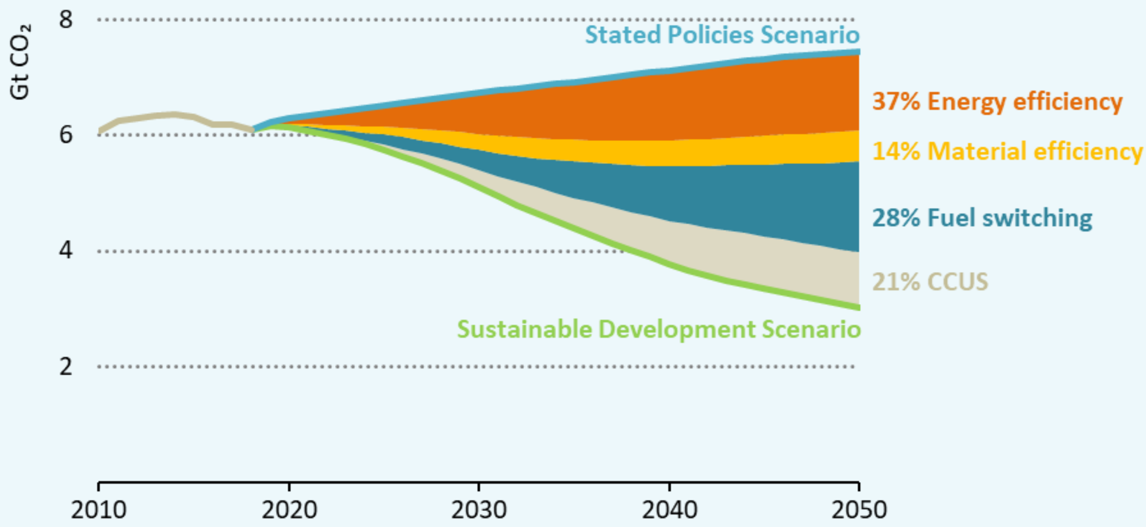

Savings by measure in energy-related CO_2 emissions from industrial final energy consumption
Source: IEA World Energy Outlook 2019, Figure 2.21

> *The largest near-term options are in energy efficiency, material efficiency and fuel switching.*

Energy efficiency is estimated to be the most important lever for industry decarbonization in the Sustainable Development Scenario. We estimate that efficiency measures can make out 37% of the decarbonization potential of the Sustainable Development Scenario compared to our baseline Stated Policies Scenario. A large part of that potential lies within less energy-intensive industries where efficiency standards for industrial motors are one of the most obvious options to reduce fossil fuel consumption besides indirect electricity use. Low efficiency motors make up about 70% of the current stock of motors in the industry sector and many of them are not covered by efficiency policies. The emissions reduction potential is large in the steel sector, particularly for coal-based processes, and efficiency improvements can be materialized all along the production chain.

Fuel switching accounts 28% of emissions reductions in industry. Both energy efficiency and fuel switching reduce oil and coal consumption by almost a third in 2050, with electricity, natural gas and bioenergy stepping in as substitutes and some use of hydrogen in the iron and steel industries, where pilot projects start around the mid-2020s.

In light industry sub-sectors and chemicals, process heat requirements in the low-temperature segment allow for high shares of electrification and fuel switching at reasonable cost, for instance through the use of heat pumps.

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In China, for example, a marked shift to electricity in light industries helps cut coal use in industry by almost 80% in 2050, relative to today. In 2050, electricity accounts for half of industrial end-use energy demand in China, almost double the share of today.

Q3. The WEO-2019 proposes an in-depth analysis of material efficiency's abatement potential. What are the key findings?

Indeed, a special effort was made in WEO-2019 to enhance understanding of material efficiency strategies in hard-to-abate sectors. Reducing demand for industrial goods through gains in material efficiency and material substitution is a key lever to bring down emissions in heavy industry. Cumulative to 2040, we expect around 14% contribution of material efficiency to overall emissions saving between Stated Policies and the Sustainable Development Scenario.

	Design	Manufacturing	Use	End-of-life
Overview	• Lightweighting. • Reduce over-design, optimise design. • Design for use, long life and reuse.	• Reduce material losses. • Reduce material overuse.	• Lifetime extension and repair. • More intensive use.	• Remanufacture and repurpose. • Direct material reuse. • Recycle.
Steel	☑ (High) Vehicle lightweighting. ☑ (Medium) Building design, reduce over-specification and concrete-steel composite construction; modular design for future materials reuse.	☑ (High) Improve steel semi-manufacturing and end-use product manufacturing yields.	☑ (High) Use buildings for longer through refurbishment. ☑ (Medium) Mode shift to reduce the number of vehicles being produced.	☑ (High) Direct reuse of steel (with highest potential in specific end-uses such as ships). ☑ (High) Recycle.
Cement	☑ (Medium) Building design, reduce over-specification and concrete-steel composite construction; modular design for future materials reuse.	☑ (Medium) Improved construction, including reducing onsite construction waste, reducing cement content in concrete and pre-cast fabrication.	☑ (High) Using buildings for longer through refurbishment.	☑ (Low) Concrete reuse.
Aluminium	☑ (Increase in demand) Vehicle lightweighting (steel-aluminium substitution) offsets some reductions from other strategies.	☑ (High) Improve aluminium semi-manufacturing and end-use product manufacturing yields.	☑ (Medium) Mode shift to reduce the number of vehicles being produced.	☑ (Medium) Direct reuse of aluminium. ☑ (High) Recycle.

☑ High potential ☑ Medium potential ☑ Low potential ☑ Increase in demand

Summary of material efficiency strategies in the Sustainable Development Scenario
Source: IEA World Energy Outlook 2019, Table 7.6

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> *Reducing demand for industrial goods through gains in material efficiency and material substitution is a key lever to bring down emissions in heavy industry.*

The analysis on material efficiency was carried out for the most energy-intensive sectors steel, cement and aluminum, and to some extent for chemicals. It systematically assesses the full value chain from design, fabrication to use and end-of-life measures. Material efficiency comprises direct strategies in industry such as reducing yield losses and other process improvements in the aluminum and iron and steel sub-sectors. Yet, the majority of savings come from systemic strategies across the energy sector (IEA, Material efficiency in clean energy transitions, 2019). For example, in the Sustainable Development Scenario, iron and steel demand in 2050 is 15% less than in the Stated Policies Scenario as a result of strategies including light weighting of cars and trucks and lifetime extension for capital stock in the buildings ; in the chemicals sector, recycling reduces the need for virgin production of plastics (IEA, The Future of Petrochemicals, 2018).

Q4. What role is CCUS meant to play for industrial decarbonization? At sub-industries level?

Further into the future, carbon capture, utilization and storage (CCUS) becomes a viable and necessary option for industrial decarbonization. A clean energy transition in the industry sector at the pace and scale depicted in the Sustainable Development Scenario is very difficult to envisage without the use of CCUS given the long lifespans of much of the capital stock and related lock-in effects, as well as the general absence of commercially available alternatives. In the Sustainable Development Scenario, about 1 Gt CO2 from the combustion of fossil fuels is captured in the industry sector in 2050, and a further 0.7 Gt from process-related emissions, on the assumption that price uncertainties are effectively addressed by governments (IEA, Energy Technology Perspectives 2017). The majority of total CO2 capture in the industry sector is in cement production with much of the remainder in iron and steel production as well as chemicals. Additional CO2 capture occurs in the refining sub-sector, and in oil and gas extraction.

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Q5. Does electrification hold promise and for what sectors?

The potential for increased electricity demand is governed by economic and technological considerations. Heat pumps can account for sizeable extra electricity demand. Low temperature heat provided by heat pumps can meet demand for heat in a wide range of industrial sub-sectors.

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In light industry, e.g. food and beverage, pharmaceuticals and textiles, low temperature heat (up to 100 °C) makes up nearly half of total heat demand. In the pulp and paper, and chemical industries, low temperature heat makes up roughly a quarter of heat demand, versus less than 5% in the cement, aluminum, and iron and steel sectors. Cement, and iron and steel, which require higher-temperature heat, are particularly hard to electrify.

Q6. Why is it so hard to electrify industry?

Electrification is especially challenging for industry and, compared with other sectors, there have been relatively few recent breakthroughs. A variety of factors explain the challenges:

1) Industrial production facilities tend to have long lifetimes and a slow turnover of capital stock. In the World Energy Model we represent the lifetimes of many competing technologies, which factors into our projections.
2) Capacity for fuel switching through electrification is limited in industry; a change in fuel often requires a change in process.
3) High temperature heat – important across most energy-intensive industries – can require significant changes to furnace design and is currently costly and not economically attractive.
4) The highly integrated nature of industrial processes means that changing one part often requires changes to other parts of a given process.

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Q7. What are the technologies that can radically decarbonize the industrial sector?

The future technical potential of innovative new technologies is nonetheless of great importance for the long-term decarbonization of the industry sector. There are a wide range of additional possibilities for electrification in industry. Setting aside uncertainty about their economic and technological feasibility of wide-scale deployment and substitution across industry, here are some of the frontier technologies to watch:

- The electrification of clinker production using induction or microwave heat offers the potential to electrify the cement sector's most energy-consuming step, though such technology is at the laboratory stage.
- Hydrogen-based direct iron reduction for primary steel production could allow for substitution from coal or natural gas to electricity – if the hydrogen is generated from electrolysis. Prevailing industry and expert views suggest that 100% electrolytic hydrogen-based steel production is not sufficiently advanced to allow for economic potential to be exploited before 2030. Partial injection of hydrogen is possible up to about a quarter without major process transformations, but is highly dependent on economics.

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- Hydrogen fuel could become an attractive option to indirectly electrify industrial high-temperature heat, either via direct combustion or blending with natural gas.
- Electro-technologies for process heat, such as infrared and ultraviolet heating (with applications in drying and curing processes), induction melting and electric boilers offer further potential for electrification across a range of industrial activities.
- Mechanical vapor recompression can provide higher temperature heat than what is currently practicable using heat pumps. Such technology could be beneficial in pulp and paper, and certain chemical production processes, though to be economical it requires low electricity prices (relative to natural gas).

Further electrification in industry could bring about better environmental performance and productivity gains which are not always factored into project economics. Such gains – in particular those connected to reductions in greenhouse gas intensity – could help to push cutting-edge electric technologies into the mainstream more rapidly.

Q8. How much investment is necessary to bring the sector in line with the Paris agreement?

Financial organizations and investors have an important role to play in guiding investment towards low emission technologies. Public funding will likely be needed in the riskier, earlier stages of innovative technology development, while private investment will become important in demonstration and particularly deployment stages. In 2018, investment in industrial energy efficiency was less than USD 40 billion and it has been relatively constant since 2015 (IEA, World Energy Investment, 2019). In the WEO-2019 baseline Stated Policies Scenario, we estimate that investment of more than USD 1.3 trillion is directed at the aggregate sector of industrial and fuel transformation cumulative to 2040. But three times this amount would be required in a scenario compatible with the Paris agreement. Accordingly, efforts have to step up now and involvement of the financial community is key to success.

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Increasingly, investors are looking for 'green' investment opportunities, motivated out a combination of ethics as well as concern about climate transition risks. Financial organizations can assist with this, by asking companies to disclose environmental performance and by responsible investment schemes or green bonds to their investors based on stringent performance criteria. Efforts are already underway on this front. For example, the Task Force on Climate-related Financial Disclosures (TCFD) is developing voluntary climate-related financial risk disclosures to better inform investors. The financial institution S&P is incorporating Environmental, Social, and Government (ESG) factors into its credit ratings. Furthermore, a consortium of sustainability and climate change investors groups has laid out a series of expectations for various industrial sectors including steel companies and construction material companies, which their investors can use for investment decisions and proxy voting.

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Through these efforts, financial organizations can help set the bar for what is acceptable CO2 performance, pushing industrial companies towards low emission investments. If enough investors partake, this could put a real constraint on the ability to build new high-emitting capacity, while making it easier to access finance for new low-emission technologies. Further development of sustainability ratings and offerings is needed to accelerate progress.

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There can also be a role for new innovative finance mechanisms. International green finance mechanisms could assist developing countries with deployment of low-emission steel technologies. Multilateral development banks can provide concessional finance for low carbon technologies. There is also potential for collaboration between public and private financial organizations, to develop blended finance mechanisms that mobilize private finance coupled with public funding taking on the higher risk.