Decarbonizing the world's industries is technically possible, say experts

January 31 2024

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Harmful emissions from the industrial sector could be reduced by up to 85% across the world, according to new research. The sector, which includes iron and steel, chemicals, cement, and food and drink, emits

around a quarter of global greenhouse gas (GHG) emissions—planet-warming gases that result in climate change and extreme weather.

A new study, led by the University of Leeds as part of its contribution to the UK Energy Research Center (UKERC), found that decarbonizing the sector is technically possible with a mix of "high and low-maturity" technologies—those that are tried and tested, along with upcoming tech that is not yet ready to be used in industry.

Lead author of the study, Ahmed Gailani, Research Fellow in Industrial Decarbonization in Leeds' School of Chemical and Process Engineering, said, "Decarbonization is a global priority for governments, companies, and society at large, because it plays such a vital role in limiting global warming.

"Our findings represent a major step forward in helping to design industrial decarbonization strategies and that is a really encouraging prospect when it comes to the future health of the planet."

Net zero target

The UK has pledged to reduce its GHG emissions to net zero by 2050, meaning it will take as much of the damaging gases out of the atmosphere as it puts in.

This new research, published in the journal *Joule*, looked at ways this could be achieved for industry. It found that established "medium to high maturity" technologies that involve carbon capture and storage, or fuel switching to hydrogen or biomass, can save on average nearly 85% of emissions in most industrial sectors.

It also suggests that low-maturity electric technologies, such as electric steam crackers—which are key equipment to produce petrochemical

products—can theoretically decarbonize between 40% and 100% of the sector's direct emissions. Other new electrification technologies can also help reduce emissions from energy-intensive processes such as steel, cement, and ceramics, which in some cases hadn't previously been thought possible.

Some of the results from the study have already been included in a consultation on enabling industrial electrification by the UK's Department of Energy Security and Net Zero.

Industrial products such as steel, chemicals and cement are widely used across the global economy. The demand for, and production of, these materials has increased significantly over recent decades, leading to high energy consumption and GHG emissions. However, global industrial emissions will need to be almost eliminated to meet the Paris Agreement targets on climate change.

Peter Taylor, a co-author of the study and Professor of Sustainable Energy Systems in the Schools of Earth and Environment and Chemical and Process Engineering at Leeds, said, "Industrial decarbonization is challenging compared to other sectors but can be achieved if evidence-based strategies are designed to enable the development of new technologies, encourage investment in related infrastructure, and reduce other barriers that make it difficult for companies to take action."

He added, "For the UK, if we don't decarbonize industry, we won't meet our climate change targets and ultimately industry will move elsewhere because, in the long term, people will be looking for products made in a clean, green way and if our industry can't produce these then it will become the industry of the past, not the industry of the future."

Additional barriers

Dr. Gailani said the study describes the sector's decarbonization as "technically possible" because although the researchers had reviewed the technologies applicable, they hadn't factored in other barriers, such as those related to social, economic or infrastructure issues.

He added, "We wanted to be explicit about the fact that our focus was the technical side of industrial decarbonization. There are of course many other barriers to overcome. For example, if carbon capture and storage technologies are needed but the means to transport CO_2 are not yet in place, this lack of infrastructure will delay the emissions reduction process. There is still a great amount of work to be done."

The uptake of many industrial decarbonization technologies is currently impacted by high capital and operational costs, even if their technical challenges can be resolved. Electrification technologies typically have two-to-three times higher operational costs compared to fossil fuel-based technologies due to the higher cost of electricity in many markets.

The study was carried out in collaboration with researchers from the University of Bath and Imperial College London, and assessed the technical potential for emission and energy savings from the most important emission-reducing technologies.

The team reviewed the published research and other sources of data to find the abatement options applicable across all sectors and their technology readiness level (TRL). They reached the figure of 85% by calculating the emission abatement potential for the most promising technologies in each sector and taking the average. The sectors analyzed were iron and steel; chemicals; cement and lime; food and drink; pulp and paper; glass; aluminum, refining and ceramics.

UKERC Director, Professor Rob Gross, said, "Industrial decarbonization is an important research priority for UKERC as finding

the most appropriate solutions requires a whole systems approach. Many of the most promising industrial abatement options rely on having access to supporting infrastructure whether that is hydrogen and CO_2 pipelines, or upgraded electricity connections."

Further research

Dr. Gailani said the research was an important first step to help policymakers understand the potential of different emission-reducing technologies that could be used in each industrial sector and therefore help them to make informed decisions about the best way forward.

However, the team also noted that further research was needed to understand the practical potential to implement these technologies in different countries and regions. This would require careful understanding of local conditions including the socio-economic context, policy, markets and regulation, business models, infrastructure, and resource availability.

More information: Assessing the potential of decarbonisation options for industrial sectors, *Joule* (2024). DOI: 10.1016/j.joule.2024.01.007. www.cell.com/joule/fulltext/S2542-4351(24)00026-6

Provided by University of Leeds