UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

MARKET ASSESSMENT ON INDUSTRIAL DECARBONIZATION INNOVATION IN DEVELOPING COUNTRIES

Technology innovation in industrial decarbonization in developing countries

Technological advancements in industrial decarbonization (ID) are essential for global efforts to combat climate change due to the significant carbon dioxide emissions produced by the industrial sector, particularly in heavy industries such as steel, cement, or chemicals. Achieving net-zero emissions demands the use of low-carbon energy, cleaner production technologies, and advanced solutions such as carbon capture, usage, and storage (CCUS). Such solutions are particularly critical in rapidly urbanizing and growing developing countries.

Initiatives like the "Accelerate-to-Demonstrate Facility" (A2D) are vital for driving these efforts, as they support the adoption and development of cleaner industrial practices.
To evaluate opportunities for accelerating industrial decarbonization innovations, a comprehensive market assessment was conducted covering all 141 countries listed as Official Development Assistance (ODA) recipients. This assessment focused on five critical areas: stakeholders, markets, technologies, projects and initiatives, and the promotion of the Sustainable Development Goals (SDGs).

Stakeholders

Six critical stakeholder groups essential for advancing ID technologies can be identified: innovators, adopters, controllers, funders, advisors, and influencers.

Innovators, including think tanks, academia, research organizations, startups, and tech companies, are pivotal for initiating and driving the development of new technologies. Adopters, such as end users, SMEs, corporations, and service companies, bring innovations to market. Controllers, including government and regulatory bodies, set policies and provide initial funding. Funders, such as banks and investment funds, provide capital for R&D and technology deployment.

Advisors, including NGOs and industrial associations, engage communities and share best practices. Influencers, including media and social media platforms, raise awareness and drive engagement.

Industrial decarbonization is highly relevant for large companies in emission-intensive sectors. New technologies can lead to significant emission reductions, thus help meeting regulatory and corporate sustainability goals. Additionally, advanced technologies can improve operational efficiency, leading to cost savings and increased productivity. They also help governments to meet their climate targets.

TABLE : Stakeholder groups

Stakeholder Groups	Innovators	Adopters	Controllers	Funders	Advisors	Influencers
Role	Develop new technologies, perform data analysis and provide technical expertise	Bring innovations to market, invest in technology development and scale up solutions	Set policies and regulatory frameworks, provide initial funding and facilitate demo projects	Provide capital for R&D and technologies deployment, and mitigate risks	Engage communities, provide on-the-ground support and share best practices	Raise awareness, facilitate collaboration and driving engagement through their platforms

Markets

The assessment focused on 28 countries which were identified as providing suitable enabling environments for investment in ID technology innovation.

The selection of these countries considered representation of different regions and income-levels. India, Brazil, Thailand, South Africa and Mexico provide strong policy frameworks that advance the adoption of clean energy technologies and display a commitment to leverage technological advancements to meet with global sustainability and climate objectives. However, few policies specifically address the development and implementation of innovative ID technology solutions.

Interventions are likely to have the most transformational impacts in countries with well-established relevant policy frameworks, large or rapidly growing populations (e.g. India and Indonesia), high rural population rates (e.g., Kenya and Nigeria), and a strong economic dependence on energy-intensive sectors (e.g., Thailand and Vietnam).

28 focus countries

Africa	Asia	Americas
Malawi	Cambodia	Domin. Republic
Rwanda	India	Costa Rica
Tanzania	Jordan	Mexico
Senegal	Kazakhstan	Panama
The Gambia	Indonesia	Brazil
Kenya	Malaysia	Ecuador
Egypt	Thailand	
Morocco		
Ghana	**Europe**	**Oceania**
Nigeria	Moldova	Papua New Guinea
Mauritius	Serbia	
South Africa		

Projects and initiatives

Various national and regional initiatives such as the Cement Breakthrough launched at COP28 which aims at promoting low-carbon emission production, as well as 32 relevant projects were identified across the 28 focus countries. An analysis of these projects shows that most of them focus on high impact technologies such as Carbon Capture, Utilization, and Storage (CCUS) and alternative fuels. Many of them are located in Asia due to the strong dependence on hard-to-abate sectors such as steel and cement production. The projects are mainly driven by private and governmental organizations, and are largely financed through grants and equity.

The analysis of ID projects shows:

- In line with national ambitions, governments and government owned institutions are very active in this area. Further, private actors play a critical role in ongoing projects as they are driven by a need for decarbonization in the respective industry and increasing regulatory scrutiny e.g., carbon pricing.
- Most of the ongoing projects are facing economic and technological constrains largely due to the highly disruptive and cost intensive nature of these technologies (e.g., as in the case of CCUS).
- This has led to most of these projects being supported by government or multilateral grants bridging the investment gap between the costs associated with these technologies.
- Adoption takes place on 2 levels: 1) industry agnostic technologies like CCUS and alternative fuels; 2) industry specific technologies which focus on switching to cleaner fuels or less emission-intensive processes.

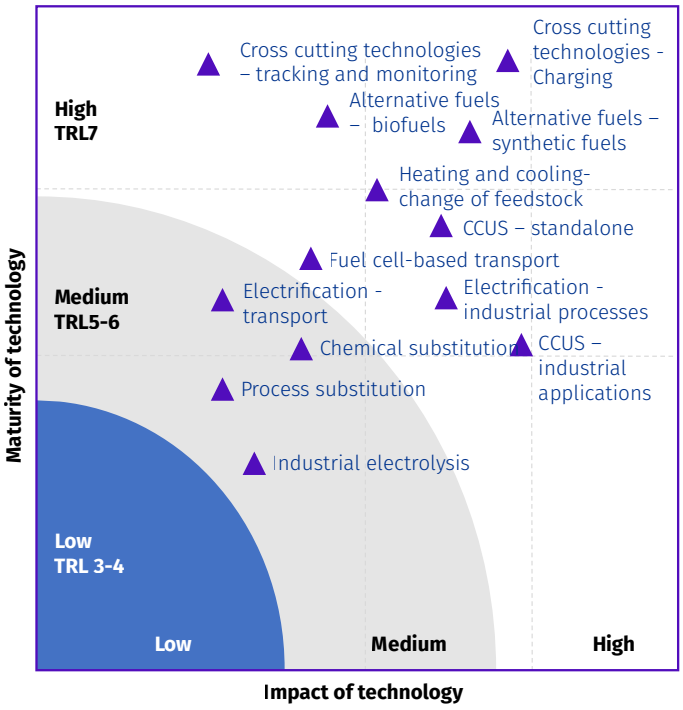
TABLE: Distribution of identified industrial decarbonization projects across key parameters

Primary Stakeholder	Primary market constraints	Funding mechanism	Technology category
Energy utility 3%	Social constraints 3%	Multiple 3%	Fuel cell technology 3%
Government 9%	Political and legal constraints 19%	Public-Private Partnership 3%	Chemical substitution 6%
Research institution/ university 13%	Economic constraints 28%	Subsidies 6%	Heating and cooling 9%
Government owned enterprise 22%	Technological and environmental constraints 50%	Incentives 16%	Alternative fuel production 13%
Private organization 50%		Equity 28%	Process substitution 25%
		Grants 44%	CCUS 44%

Technologies

Key technologies include CCUS, alternative fuels like biofuels and hydrogen for industrial applications, process optimization to enhance energy efficiency and reduce emissions, and electrification to facilitate a transition from fossil fuels to electricity in industrial processes. Least developed countries (LDCs) primarily rely on relatively mature and cost-efficient technologies such as alternative fuels. However, as income levels increase, countries tend to invest in more innovative, high-impact technologies.

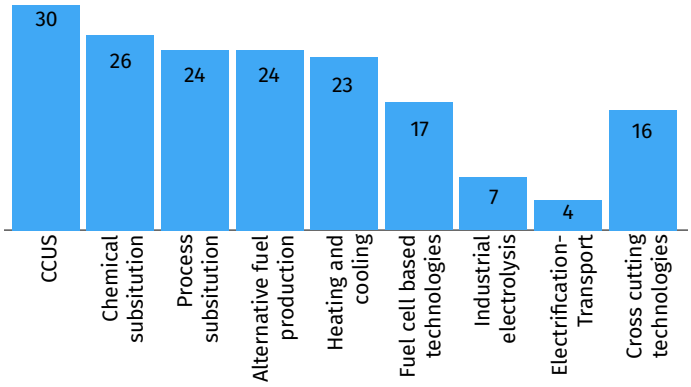
TABLE: Technology maturity map



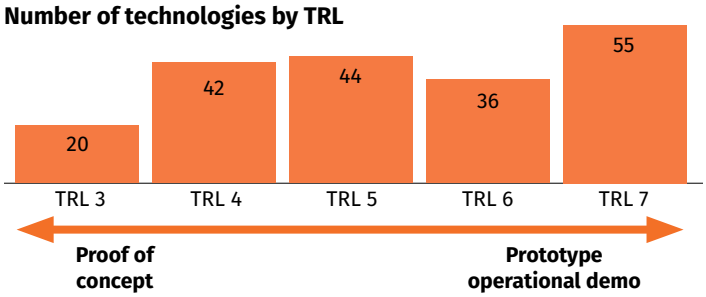
In the area of industrial decarbonization approximately 200 technologies across TRLs 3-7 were identified and assessed. Most of these technologies are in the post-conception phase, with nearly 50% at the prototype or pilot testing stages. The technologies can be broadly categorized into six major groups, with CCUS being the most researched one globally.

TABLE: Technology types and distribution among TRLs

Number of technologies by tech type



Number of technologies by TRL



Regional insights reveal varied adoption patterns.

In **Africa**, the emphasis is on mature and cost-effective technologies due to limited infrastructure and capital, with a focus on biofuel production and solar technologies.

In **Asia**, there is greater adoption of innovative technologies supported by relatively advanced infrastructure and policies, with pilot projects in sustainable fuel production and hydrogen applications.

The **Americas** exhibit significant activity in both mature and emerging solutions, with projects in CCUS, alternative fuels, and hydrogen applications. Despite high capital availability, regulatory frameworks in these regions can be slow to support new technologies.

Impacts and promotion of SDGs

Industrial decarbonization technologies are particularly impactful in promoting SDG 9 (Industry, Innovation, and Infrastructure) and SDG 13 (Climate Action). Relevant technologies enable the replacement of emission-intensive processes with low-carbon alternatives, thereby improving efficiency and significantly reducing greenhouse gas (GHG) emissions. Switching to renewable energy sources (e.g., solar and wind power) can substantially lower carbon emissions within industrial sectors, and biomass can serve as a less carbon-intensive alternative to traditional fossil fuels. Moreover, the implementation of energy-efficient manufacturing processes, such as advanced heat recovery systems and electrification of industrial heat, can minimize energy consumption and emissions.

Key technologies	1 NO POVERTY	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	13 CLIMATE ACTION	Co-Benefit SDGs	Rationale for Co-Benefit SDGs
CCUS				7, 12	Enable cleaner energy systems and promote resource efficiency and waste reduction through innovative carbon utilization
Biorefining				7, 12	Provides renewable and clean energy sources and promotes innovative resilient infrastructure
Post-combustion: solid adsorption (coal / biomass with CCUS)				7, 12	Reduces carbon emissions from existing energy infrastructure and promotes innovation
Solid oxide fuel cells				8, 11	Creates new jobs and enhances sustainability and resilience of infrastructure
Electricity in the Bayer process				7, 12	Contributes to clean energy production, and promotes responsible production practices
Biomass gasification (ammonia)				7, 12	Provides a clean energy source, reduces waste and promotes responsible production practices
Ultra-fast charging				7, 11	Facilitates the widespread adoption of EVs and contributes to the development of sustainable transport
Automated and connected vehicles (level 4+)				3, 11	Decreases traffic related injuries and fatalities, and improves urban mobility

CCUS technologies also provide a notable example of how technologies can contribute to climate action while fostering infrastructure development for continued economic and industrial development. They capture CO_2 emissions from industrial processes, utilize the captured carbon in various applications, or store it underground. Thus, they support SDG 9 by enabling companies in hard-to-abate industries such as cement, steel, or chemicals, to stay in business while improving their environmental impact. Moreover, CCUS can use existing infra-structure in innovative ways to make these emission-intensive sectors cleaner. Additionally, SDG 13 is promoted through the removal of GHG-emissions from the atmosphere, helping heavy industries to align with global efforts to mitigate climate change and limit global temperature rise.

There are also co-benefits for other SDGs. CCUS support SDG 7 (Affordable and Clean Energy) by enabling cleaner energy production when integrated with power plants, reducing the carbon footprint of fossil fuel-based energy generation. Furthermore, they contribute to SDG 12 (Responsible Consumption and Production) by promoting the efficient use of captured carbon to produce new materials, such as carbonates, fuels, and chemicals, thereby enhancing resource efficiency and reducing waste.

Funded by: UK Government

Developed by: KPMG

Download the entire executive report here:

Vienna International Centre
Wagramerstr. 5, P.O. Box 300,
A-1400 Vienna, Austria

https://a2dfacility.unido.org

A2DFacility@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION