UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Progress by innovation

A2D
Accelerate to Demonstrate Facility

MARKET ASSESSMENT ON SMART ENERGY AND INDUSTRIAL DECARBONIZATION INNOVATION IN DEVELOPING COUNTRIES

November 2024

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Acknowledgement

This market assessment was conducted by KPMG Austria under the overall guidance of Mr. Peter Warren, A2D Facility Manager, and Ms. Yi Zhang, A2D Facility Smart Energy and Industrial Decarbonization Project Coordinator, within the Division of Climate Innovation and Montreal Protocol of the United Nations Industrial Development Organization (UNIDO). This effort was made possible through the support of the United Kingdom's Department for Energy Security and Net Zero (DESNZ).

Authors from KPMG Austria: Wolfgang Ritzberger, Adela Roszkowski, Markus Schiffer

Authors from KPMG US: Ruba Amarin

Authors from KPMG Global Services: Ambareesh Soman, Nikhil Kaushik

The project team extends their gratitude to the survey respondents and interviewed experts (Appendix page 83, Experts interviewed) for their precious time and insights.

About UNIDO

UNIDO is a specialized agency of the United Nations with a unique mandate to promote, dynamize and accelerate industrial development. Our mandate is reflected in Sustainable Development Goal (SDG) 9: “Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”, but UNIDO’s activities contribute to all the SDGs.

UNIDO’s vision is a world without poverty and hunger, where industry drives low-emission economies, improves living standards, and preserves the livable environment for present and future generations, leaving no one behind.

Table of contents

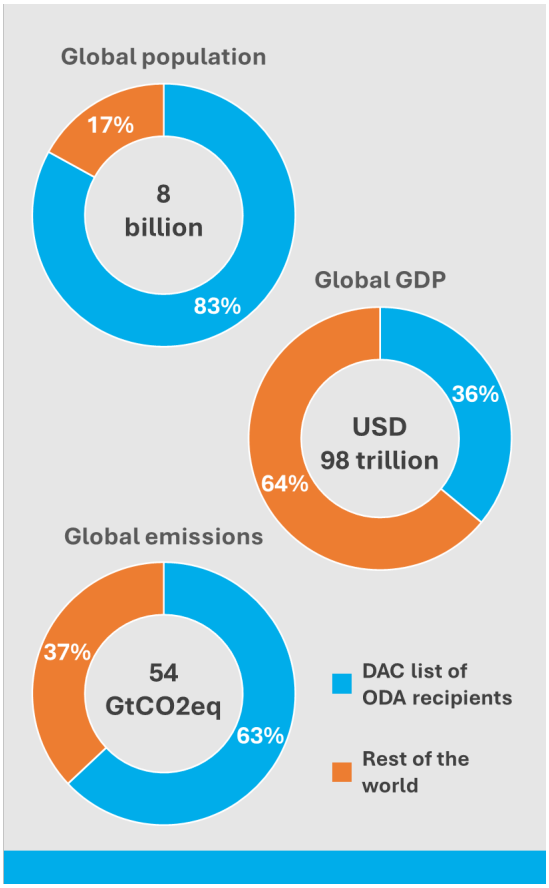
Table of figures

1. Executive summary

1.1. Background

The A2D Facility, which is funded by the UK Government's Department of Energy Security & Net Zero (DESNZ), aims to accelerate the commercialization of innovative clean energy technologies in developing countries. It focuses on four thematic areas: clean hydrogen, critical minerals, smart energy, and industrial decarbonization. These areas are crucial for facilitating clean energy transitions and addressing climate risks in developing countries, which currently account for 83% of the world's population and 63% of global emissions.

***Figure a**: ODA Recipients Population Share, Emissions and GDP Contributions*



The A2D Facility closes an important gap in the landscape of climate innovation funds that support developing countries through international climate finance and Official Development Assistance (ODA). It targets the pilot demonstration phase of the climate innovation chain, focusing on projects with a "lighthouse" effect that have the potential for a transformational impact in supported countries.

This document summarizes the results of a comprehensive examination of two of the thematic areas, i.e., smart energy and industrial decarbonization. **Smart energy** refers to systems and applications using digital technologies, which enable more efficient network delivery and usage of energy. Such technologies and solutions may include, but are not limited to, smart grids, smart devices, energy storage systems, Artificial Intelligence software or solutions, data access and management tools such as blockchain, smart metering, remote monitoring and controls, demand-side response, and the integration of on-grid and off-grid approaches (e.g., swarm grids, mini-grids, etc.).

Industrial decarbonization is the process of strategic reduction or elimination of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions from the industrial sector. This can be achieved by switching to low-carbon energy sources, adopting cleaner production methods, and improving energy efficiency. Decarbonization can be materialized at the level of source, process, and life cycle. In the context of technological solutions, the assessment emphasized on carbon capture, utilization, and storage (CCUS), alternative fuels such as biofuels and hydrogen for industrial applications, process optimization to enhance energy efficiency, and electrification of industrial processes.

Innovative technologies in these thematic areas provide affordable energy access, accelerate clean energy transitions, and drive economic growth while addressing environmental challenges.

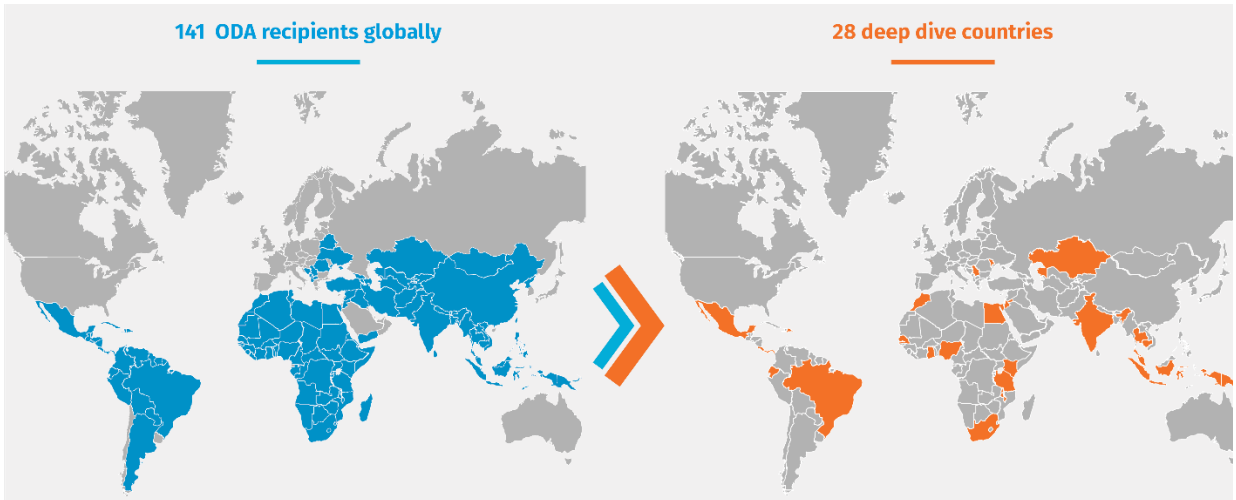
The market assessments (one for each thematic area) served to identify high-potential markets, technologies, and project pipelines, with the objective of accelerating the commercialization of innovative clean energy technologies in developing countries.

1.1.1. Country Selection

While the assessments provide a global view covering all 141 ODA recipient countries, a representative set of 28 countries were selected for deep dive analysis.

The criteria for selecting those focus countries were based on several key factors including the presence of progressive policy frameworks and regulatory environments that support technology innovation in smart energy and industrial decarbonization. Additionally, countries with significant economic growth potential, high energy demand, and vulnerability to climate change were prioritized. A balanced selection across Africa, Asia, and Latin America ensured a diverse geographical and economic context. The selected focus countries are:

***Figure b**: Overview of focus countries Contributions*



Africa	Asia	Americas
1. Malawi	13. Cambodia	22. Domin. Republic
2. Rwanda	14. India	23. Costa Rica
3. Tanzania	15. Jordan	24. Mexico
4. Senegal	16. Kazakhstan	25. Panama
5. The Gambia	17. Indonesia	26. Brazil
6. Kenya	18. Malaysia	27. Ecuador
7. Egypt	19. Thailand	
8. Morocco		
9. Ghana	**Europe**	**Oceania**
10. Nigeria	20. Moldova	28. Papua New Guinea
11. Mauritius	21. Serbia	
12. South Africa		

1.2. Key findings of the market assessment

Both market assessments cover five core areas of analysis which are critical for the advancement and scaling of respective innovative technologies: stakeholders, markets, projects and initiatives, technology landscape, as well as impacts and SDGs.

While certain findings within these analytic core areas, e.g. for the technology landscape, are distinctive for each thematic area, others clearly stand out as cross-cutting results since they encompass enabling environments, stakeholder interactions, and policy frameworks that are crucial for advancing technology innovation across both areas equally.

Subsequently, distinctive and cross-cutting results are marked with respective icons:

SE ID SE ID

1.2.1. Stakeholders

SE ID Six critical stakeholder groups have been identified, including innovators, adopters, controllers, funders, advisors, and influencers, all of whom play essential roles in advancing technology innovation in both the two thematic areas of smart energy and industrial decarbonization.

Each stakeholder group contributes in different ways to the innovation process and is comprised of different sub-groups. For example, innovators such as think tanks, academia, research organizations, startups, and tech companies are pivotal in developing new technologies, performing data analysis, and providing technical expertise. Adopters, including end users, SMEs, large users, service companies, and the private sector, are responsible for bringing innovations to market, investing in technology development, and scaling up solutions. Controllers, such as government bodies, regulatory bodies, and certification bodies, set policies and regulatory frameworks, provide initial funding, and facilitate demonstration projects. Funders, including banks, donors, financial bodies, and investment funds, provide capital for R&D and technology deployment and mitigate risks. Advisors, such as NGOs, energy associations, industrial associations, and consultants, engage communities, provide on-the-ground support, and share best practices. Influencers, including media, social media influencers, and associations, raise awareness, facilitate collaboration, and drive engagement through their platforms.

Figure c: *Stakeholder groups´ level of involvement by TRL*

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
TRL 3-4	High	Low	Limited	High	High	Low
TRL 5-6	High	Limited	High	High	High	Limited
TRL 7-8	High	High	High	High	High	High

High Limited Low

In both thematic areas the relationship between innovators and adopters is marked by a collaborative approach Notably, there is significant collaboration between controllers (government), adopters (private sector), and advisors (NGOs) to implement and scale up clean energy end solutions through public-private partnerships (PPPs).

In general, the relevance of each stakeholder group varies along the technology innovation development process. At Technology Readiness Levels (TRL) 3-4, innovators and advisors are highly engaged in developing and refining the technology, while funders provide the required initial financial support. At TRL 5-6, adopters and controllers become more involved, with increased funding and engagement in implementation. By TRL 7, all stakeholders are significantly engaged: adopters integrate the technology into operations, controllers ensure compliance, and funders provide substantial investments for large-scale demonstrations.

While the main beneficiaries tend to be adopters and controllers in both smart energy and industrial decarbonization, the benefits vary across the two thematic areas, hence serving different sub- categories of beneficiaries.

SE **Smart energy** solutions play a particularly critical role for local communities and end users living in regions with poor energy access. Women, especially in rural areas, tend to be most affected by energy scarcity; access to smart energy solutions can reduce their workload and empower them economically.

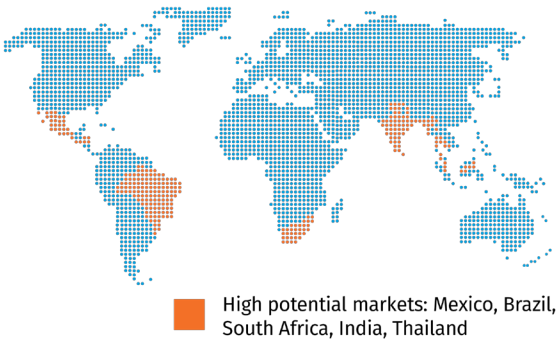
ID **Industrial decarbonization** is particularly relevant for large companies in emission-intensive sectors. New technologies can lead to significant emissions reductions, thus help meeting regulatory and corporate sustainability goals.

Additionally, advanced technologies can improve operational efficiency, leading to cost savings and increased productivity. Beyond that, they also help governments meeting their climate targets.

1.2.2. Markets

Official Development Assistance (ODA) recipient countries vary significantly across a wide range of dimensions, including income levels, economic performance, political stability, contribution towards Sustainable Development Goals (SDGs), emission reduction ambitions, access to clean energy, and the maturity of policy frameworks. Performance across these dimensions determines the extent to which these countries provide enabling environments for technology innovation.

Figure d: *High potential markets*



SE ID **Both market assessments** show a rich policy landscape existing across developing countries related to emission reductions, energy efficiency, and sustainability. High-potential markets include India, Brazil, Thailand, South Africa, and Mexico, as they provide strong enabling environments and policy frameworks which advance the continued reduction in the costs of renewable energy technologies, making them more accessible. There is a commitment to align technological advancements with global sustainability and climate objectives, yet few policies address innovative technology solutions specifically which highlights the need for more targeted policies that support the development and deployment of cutting-edge technologies in both SE and ID. Overall, interventions in these countries, which have set ambitious targets and established strong policy frameworks, are likely to have the most transformational impacts.

Generally, the potential for transformational impact is highest when economic, social, and environmental aspects converge.

SE ID **Both market assessments** show a rich policy landscape existing across developing countries related to emission reductions, energy efficiency, and sustainability. High-potential markets include India, Brazil, Thailand, South Africa, and Mexico, as they provide strong enabling environments and policy frameworks which advance the continued reduction in the costs of renewable energy technologies, making them more accessible. There is a commitment to align technological advancements with global sustainability and climate objectives, yet few policies address innovative technology solutions specifically which highlights the need for more targeted policies that support the development and deployment of cutting-edge technologies in both SE and ID. Overall, interventions in these countries, which have set ambitious targets and established strong policy frameworks, are likely to have the most transformational impacts.

Generally, the potential for transformational impact is highest when economic, social, and environmental aspects converge. African countries such as Rwanda, Gambia, Kenya, and South Africa stand out due to high rural population rates and relatively mature policy frameworks. These countries present unique opportunities for impactful interventions due to their demographic and policy characteristics. In Asia, populous countries like India and China depend heavily on hard-to-abate industries, presenting significant opportunities for impactful interventions. Most countries in the Americas are economically better-developed (Upper Middle-Income Country category), yet their policies largely focus on technologies that do not support innovation. Therefore, strategic interventions in these regions should aim to bridge the gap between existing policy frameworks and the need for innovative technology solutions to maximize the transformational impact.

SE ID Critical market constraints hindering the adoption of innovative technologies in both smart energy and industrial decarbonization fall into four main categories: 1) political and legal, 2) economic, 3) technological and environmental, and 4) social. While technology innovation in both thematic areas is essentially affected by the same types of market constraints, the relevance of these constraints may differ across countries, industries, and technologies.

1.2.3. Projects and initiatives

The market assessments for both thematic areas, revealed a comprehensive landscape of initiatives and projects that align with both national and international sustainability goals. Developed countries such as the EU member states, Canada, and the UAE, along with global industry bodies like the Global Cement and Concrete Association, are leading the way through large-scale regional and global initiatives. However, the success of these externally sponsored initiatives in developing countries hinges on the presence of supportive policies and incentives.

The project database established through the assessments highlights a broad spectrum of projects across various technologies, including smart grids, Carbon Capture, Utilization, and Storage (CCUS), and alternative fuels production. This diversity demonstrates extensive opportunities for investment in innovative projects across the DAC list of ODA recipients. Many of these projects are pioneering in their respective fields, employing cutting-edge technologies such as the development of aqueous carbon capture technologies, which could serve as benchmarks for future initiatives globally. Strong collaborations between public, private, and international stakeholders, including ministries, Multilateral Development Banks (MDBs), and IGOS such as the United Nations Environment Programme (UNEP), are evident. Additionally, the presence of multiple financial mechanisms, including crowdsourcing and various combinations, reflects an open landscape for new and innovative forms of financial support.

SE In the realm of **smart energy**, utilities emerge as pivotal players, acting as key adopters and implementers of technologies such as smart grids and virtual power plants. The highly innovative nature of these technologies has introduced significant technological, political, and legal constraints, primarily driven by privacy and security concerns. Despite these challenges, the

majority of smart energy projects are buoyed by government grants, as governments aim to foster projects that will catalyze further interest and investment from various stakeholders. Among the smart grid technologies, market-enabling mechanisms like Virtual Power Plants (VPPs) are witnessing the most activity due to their cost-effectiveness and supportive characteristics for renewable and distributed technologies. Furthermore, there is substantial momentum towards upgrading to smart grids, motivated by the growing need for flexibility and the integration of renewable energy sources into the grid.

***Figure e**: Distribution of key parameters of identified SE projects*

SE

Primary Stakeholder	Primary market constraints	Funding mechanism	Technology category
IGOs 4%	Social constraints 0%	Multiple 4%	Digital Technologies 8%
Foreign government 4%	Economic constraints 17%	Subsidies 4%	Automation technologies 8%
Research institutions 8%	Political and legal constraints 29%	Crowdfunding 4%	Smart grid enablers - Infratech 13%
Government owned enterprise 8%	Technological and environmental constraints 54%	Incentives 8%	Smart grid networks 25%
Government 13%		Loans 13%	Smart grid enablers-market mechanisms 46%
Private organization 29%		Equity 25%	
Energy utility 34%		Grants 42%	

ID Turning to industrial decarbonization, both governments and government-owned institutions are deeply involved, aligning with national ambitions. Private players, driven by the necessity for decarbonization in their respective industries and increasing regulatory scrutiny such as carbon pricing, lead most ongoing projects. However, these projects face substantial economic and technological constraints due to the disruptive and cost-intensive nature of the technologies involved, especially Carbon Capture, Utilization, and Storage (CCUS).

Consequently, these projects are principally supported by government or multilateral grants that help bridge the financial gaps associated with these advanced technologies. Within this domain, significant adoption is observed across two primary technology categories: industry-agnostic technologies like CCUS and alternative fuels, as well as industry-specific technologies focused on switching to cleaner fuels or alternative processes.

Figure f: *Distribution of key parameters of identified ID projects*

ID

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%

Moreover, lighthouse projects were identified that are recognized not only for their immediate impacts but also for their potential scalability and replicability. These projects demonstrate cutting-edge technology, best practices, or novel approaches in smart energy and industrial decarbonization, showcasing the potential and benefits of new and innovative solutions.

SE In the field of smart energy, projects like the Evolve Virtual Power Plant in South Africa and smart grid networks in India and Indonesia are particularly noteworthy. The Tata Power DDL AI Enabled Smart energy Management System in India exemplifies how Artificial Intelligence (AI) and machine learning can optimize energy distribution and consumption. This project's scalable model can be replicated across other regions, promoting energy efficiency on a broader scale.

Strong collaborative efforts across key stakeholders, including government bodies, private investors, and multilateral agencies, have been a critical success factor. For instance, the Mae Hong Son Smart Grid Pilot Project in Thailand serves as a knowledge hub for smart grid technologies in rural settings, enhancing local capacities and offering insights into sustainable energy management that can be shared globally.

ID In the area of industrial decarbonization, notable projects include the Indian Oil Corporation Koyali Refinery Project and the NoNSToP Project located in Egypt. The Koyali

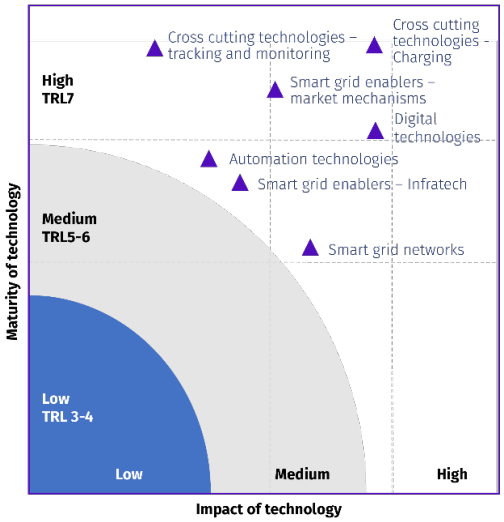
Refinery Project in India focuses on capturing carbon dioxide emissions from hydrogen generation units, aiming to significantly reduce the refinery's carbon footprint and serve as a model for similar initiatives globally, illustrating the benefits of integrating carbon capture technologies in industrial processes. The Nonstop Project is dedicated to developing a cost-effective solar concentrating photovoltaic system, which aims to increase energy output and make solar energy more accessible and affordable. The project's innovative approach could significantly impact the adoption of renewable energy, especially in regions with high solar irradiance.

1.2.4. Technology landscape

Both market assessments reveal a dynamic landscape of technological innovations that are pivotal for advancing sustainability goals.

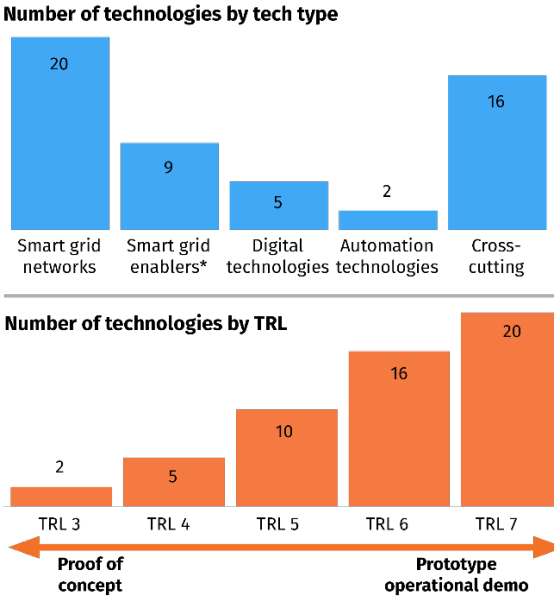
SE In the realm of smart energy, innovation is primarily focused on enhancing the robustness, efficiency, and flexibility of the electricity grid. This is crucial for the seamless integration of variable renewable energy sources and energy storage solutions. Key technologies in this area include smart grid enabling technologies and market mechanisms such as demand response and virtual power plants. The advent of digital technologies such as Artificial Intelligence, Machine Learning, Blockchain, and the Internet of Things is revolutionizing energy infrastructure, making it smarter and more connected. These technologies are increasingly integrated into energy systems and industries to enhance productivity and improve energy efficiency. Significant uptake is being witnessed in large middle-income countries such as India and Indonesia, which are transitioning to improved and connected electricity grids to cater to growing and variable primarily focused on more mature grid and storage technologies.

Figure g: *SE technology maturity map*



Approximately 50 relevant smart energy technologies within the Technology Readiness Level (TRL) range 3 to 7 were identified and assessed. Most of these technologies are currently in the post-conception phase, with nearly 50% at the prototype or pilot testing stages.

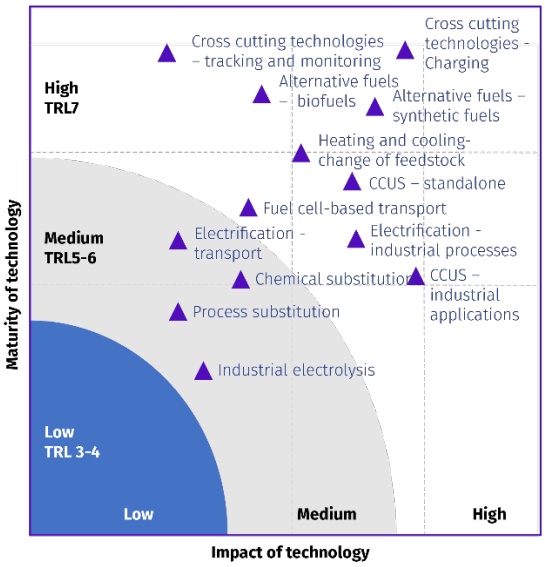
Figure h: *SE technology types and distribution among TRLs*



Technologies in the TRL range from 6 to 7 can offer benefits due to their advanced degree of maturity. Since they have demonstrated their feasibility and effectiveness in pilot projects, already existing results bolster confidence in their potential, thus limiting technical and financial risks. Such derisking may be of particular relevance in developing country contexts where various risks are likely to be higher than in more developed regions, thus exceeding the risk-appetite of investors and stakeholders and discouraging their engagement. Additionally, governments and regulatory bodies are typically more inclined to support the deployment of well-validated technologies, which can help create supportive policy frameworks and incentives such as subsidies and tax benefits. More mature technologies may also allow for quicker deployment compared to earlier-stage innovations, leading to faster realization of benefits.

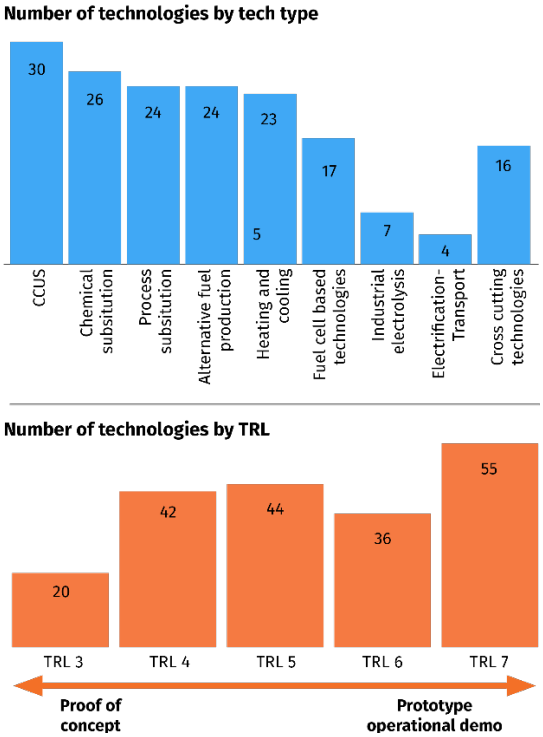
ID In the field of **industrial decarbonization**, innovation is centered on replacing incumbent, emission-intensive technologies with low-carbon alternatives. Key target areas include the substitution of industrial fuels, materials, and processes with more efficient and cleaner technologies. In hard-to-abate sectors such as metals and mining, chemicals, and petrochemicals, there is significant traction in developing and prototyping various types of Carbon Capture, Utilization, and Storage technologies, with a focus on improving efficacy and making these technologies more viable. LDCs primarily rely on relatively mature and cost-efficient technologies. However, as income levels increase, countries tend to invest in more innovative and scalable decarbonization technologies such as CCUS, alternative fuel production, and the use of hydrogen in industrial processes.

Figure i: *ID 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 Carbon Capture, Utilization, and Storage (CCUS) being the most researched one globally.

Figure j: *ID technology types and distribution among TRLs*



SE ID Certain technologies create a cross-cutting impact by improving overall process and energy efficiency, as well as aiding in decarbonization. These include advanced charging technologies such as ultra-fast charging and inductive charging, monitoring technologies, and technologies related to battery recycling. These technologies have a significant digitalization component and contribute to the decarbonization of specific industries by enhancing material and energy efficiency. The integration of these cross-cutting technologies is essential for achieving broader sustainability goals and ensuring that both smart energy and industrial decarbonization efforts are effective and scalable.

1.2.5. Impacts and SDGs

The promotion of the Sustainable Development Goals (SDGs) occurs on at least two levels: country level and technology level. Accordingly, the underlying theories of change will differ.

The degree to which each country provides an enabling environment for clean energy and decarbonization technology innovation and technology adoption, in turn, impacts the promotion of the SDGs at the country level, creating a dynamic interplay between national policies and technological advancements. The 28 focus countries currently drive innovation in SE and ID with a comparable set of major initiatives, with some regional initiatives spanning across several countries.

Figure k: *Snapshot of national initiatives in the Americas*

Country	Number of initiatives
Brazil	7
Mexico	2
Costa Rica	1
Panama	1
Dominican Republic	1
Ecuador	1
Technology focus	
Smart Energy	**Industrial Decarbonization**
Smart grids	Sustainable fuels
Energy storage systems	Circular economy
Integrating renewable energy (RE) resources	

In the Americas, a notable smart energy initiative is “REnovables in Latin America and the Caribbean” (RELAC). This initiative includes 16 member countries and is driven by stakeholders such as the National Renewable Energy Laboratory (NREL), the Global Climate Action Partnership (GCAP), and the Inter-American Development Bank (IDB). RELAC focuses on developing country-specific energy storage action plans, providing capacity building, strategic planning support, and technical assistance. Additionally, it aims to create a stakeholder network for knowledge exchange and regional dissemination of content. The project is funded by IDB and NREL, showcasing the central role of international collaboration in advancing energy storage solutions.

Figure l: *Snapshot of national initiatives in Africa and Europe*

Country	Number of initiatives
Moldova	4
Serbia	1
South Africa	6
Ghana	6
Nigeria	6
Kenya	4
Rwanda	3
Mauritius	1
Egypt	1
Technology focus	
Smart Energy	**Industrial Decarbonization**
Smart grids	Sustainable fuels
Energy storage systems	Circular economy
Energy efficiency	Energy efficiency

SE The assessment identified several key regional initiatives in the realm of smart energy across Africa. Notable actions including “Smart Energy Solutions for Africa” which is active in many of the selected deep dive countries such as Ghana, Kenya, Malawi, Morocco, Nigeria, Rwanda, South Africa, and Tanzania. Another significant initiative is the ”Energizing Development,” focusing on Kenya, Nigeria, Ghana, Rwanda, Malawi, Senegal, and Tanzania. These projects receive funding from a mix of public and private sources, supported by international development agencies.

ID In the area of industrial decarbonization, the assessment highlights the “Project Development Program” and the “African

Circular Economy Alliance (ACEA)." ACEA operates across 13 African countries, promoting material efficiency and circular economy practices. The alliance backs policy development and advocacy, and the scaling of circular economy projects, with financial support from a multi-donor trust fund. The activities include policy development, stakeholder engagement, and support for innovative micro-, small-, and medium-sized enterprises (MSMEs), including financial support, market access, and network building.

Figure m: *Snapshot of national initiatives in Asia and Oceania*

Country	Number of initiatives
India	9
Cambodia	6
Indonesia	4
Papua New Guinea	3
Kazakhstan	2
Thailand	2
Jordan	1
Technology focus	
Smart Energy	**Industrial Decarbonization**
Smart grids	CCUS
Big data	Sustainable fuels
Energy storage systems	Circular economy
Smart grids	Energy efficiency

SE In Asia and Oceania there is a focus is on improving energy efficiency, smart grids, and battery energy storage systems (BESS). Efforts aim at enhancing the technical infrastructure and operational efficiency. For instance, the "Asia-Pacific Economic Cooperation (APEC) Smart Grid Initiative" promotes smart grid technologies across the region on order to

economically, the adoption of advanced decarbonization technologies such as CCUS, alternative fuel production, and hydrogen utilization in industrial processes becomes increasingly viable, further promoting sustainable industrial growth.

address energy challenges such as security, resilience, efficiency, and sustainability.

SE Smart energy technologies hold substantial potential for promoting SDG 1 (No Poverty). Smart grids and decentralized energy systems exemplify how theories of change can be articulated to support technology innovation in smart energy within developing country contexts, addressing the most relevant SDGs. By enhancing energy access and reliability, these technologies can drive economic growth, improve living standards, and reduce poverty. The integration of digital technologies such as AI, ML, and the IoT into energy systems further amplifies these impacts by optimizing energy distribution and consumption, thereby fostering sustainable development.

ID Industrial decarbonization technologies are particularly impactful in promoting SDG 9 (Industry, Innovation, and Infrastructure) and SDG 13 (Climate Action). Innovations in this area focus on replacing emission-intensive technologies with low-carbon alternatives, thereby driving industrial efficiency and reducing greenhouse gas emissions. CCUS technologies provide a compelling example of how theories of change can be formulated to support technology innovation in industrial decarbonization within developing country contexts. By capturing and repurposing carbon emissions, these technologies contribute to climate action while fostering industrial innovation and infrastructure development. As countries progress

1.3. Conclusion and way forward

The heterogeneity across the identified critical stakeholder groups, their different roles, and varying degree of engagement along the technology innovation development process shows that there is a multifaceted and complex ecosystem which drives and shapes technology innovation in both thematic areas. Understanding the landscape of key player and facilitating the interactions between the relevant stakeholders is key to advancing and accelerating clean technologies, especially those requiring a mix of specialized expertise and significant financial investments. This includes:

- Facilitating knowledge transfer for local stakeholders, including government officials, industry leaders, and community members, could support the establishment of critical expertise for implementing and maintaining new technologies, thereby enhancing the sustainability and scalability of projects.
- Collaborating with private sector companies, industry associations, and NGOs can further enhance the scalability, replicability, and overall deployment of innovative solutions.
- Public-private partnerships can provide access to additional resources, expertise, and funding. For example, technology companies can offer specialized training on their products, while industry associations can help identify skill gaps and training needs.

Furthermore, ensuring that interventions are inclusive and equitable is critical, particularly in rural areas where women and minorities are disproportionately affected by energy scarcity. Empowering women through access to smart energy solutions can lead to significant socio-economic benefits. Ensuring access to energy and training in the maintenance and operation of these systems can empower women economically and socially and enable them to become active participants in the energy transition.

While all developing countries can benefit greatly from advances in clean technology solutions, some countries stand out in the potential they have given their economic development, population size and maturity of relevant policy frameworks. Amongst those countries are India, Brazil, Mexico, South Africa, and Thailand.

The assessment revealed that a wide range of technologies across the TRL range 3 to 7 exist to date, with some notable lighthouse projects providing guidance on how innovative technology solutions in SE and ID can be successfully scaled and be applied as a new solution in different contexts.

While technologies at the earlier development stage may prove to be crucial for future efforts to combat climate change, technologies with a higher development grade have already demonstrated their feasibility and effectiveness. This implies a significant reduction of the technical and financial risks associated with their implementation, making them more attractive to investors and stakeholders with a lower risk-appetite. Governments and regulatory bodies, for example, tend to be more likely to support the deployment of technologies that have been validated in real-world conditions. The higher maturity of technologies allows for quicker deployment compared to earlier-stage technologies, leading to more immediate impacts on energy efficiency, emissions reduction, and economic development, thus making the contribution towards combating climate change and achieving the SDGs more easily tangible.

2. Introduction – background and market assessments

2.1. About the A2D Facility

According to the International Energy Agency (IEA, 2023), approximately 35% of the emissions reductions needed to achieve a global net-zero scenario by 2050 must derive from technologies currently in the demonstration or prototyping phase.

This underscores the importance of accelerating the commercialization of innovative technologies which enable the supply of clean energy and the reduction of industrial emissions. The UK Government's Department of Energy Security & Net Zero (DESNZ) has committed and initial GBP 65 million (approx. USD 80 million) to run the A2D Facility with UNIDO to provide additional support to the existing landscape of relevant technology innovation projects.

The A2D Facility is a global program that provides support to countries that are eligible to receive development funding, i.e., Official Development Assistance (ODA), as defined by the OECD's Development Assistance Committee (DAC). Currently, this list includes 141 countries which together account for 83% of the global population. While emissions and exposure to climate risks are both increasing in developing countries, poverty, access to energy and advancing prosperity through economic and industrial development remain significant challenges.

Developing countries are amongst the most vulnerable to environmental and climate-related risks. Least developed countries (LDCs) perform particularly poorly on the Notre Dame Global Adaptation Initiative (ND-GAIN) country index with a score of 38 compared to an average of 68 across upper middle-income countries (UMIC), indicating that there is a low degree of preparedness to deal with climate risks where poverty levels are high.

Total GDP of all ODA recipients accounts for 36% of global GDP, and GDP per capita is approximately one tenth across LDCs and about one fifth compared to the global average of USD 12.261 p.a. (2021). Significant parts of the population in LDCs and lower middle-income countries (LMICs) live below the international poverty line. There is also a clear correlation between the level of economic development GHG emissions: the poorest countries exhibit the lowest per capita GHG emissions.

Figure 1: *ODA Recipients Population Share, Emissions and GDP Contributions*

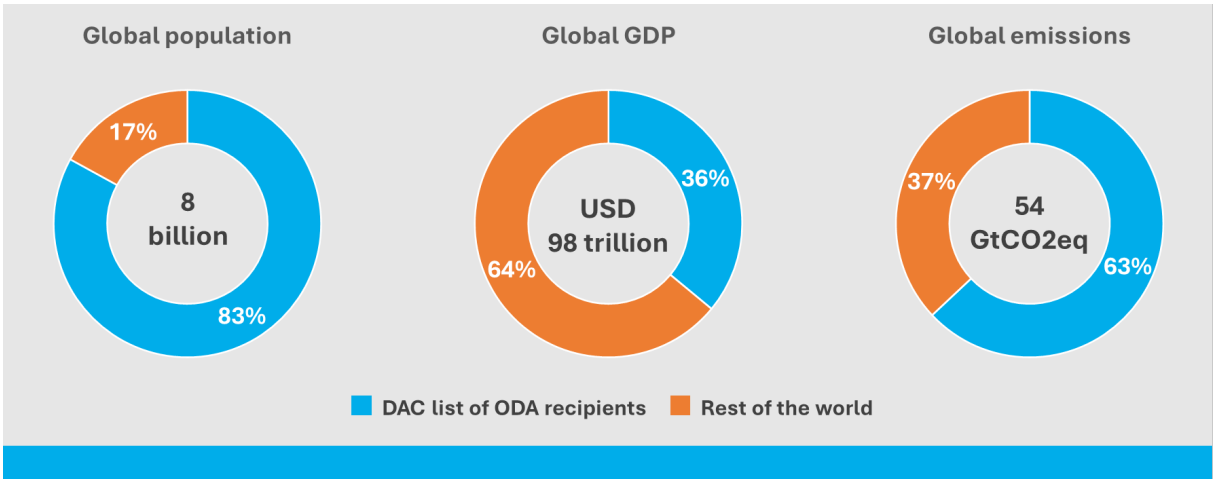
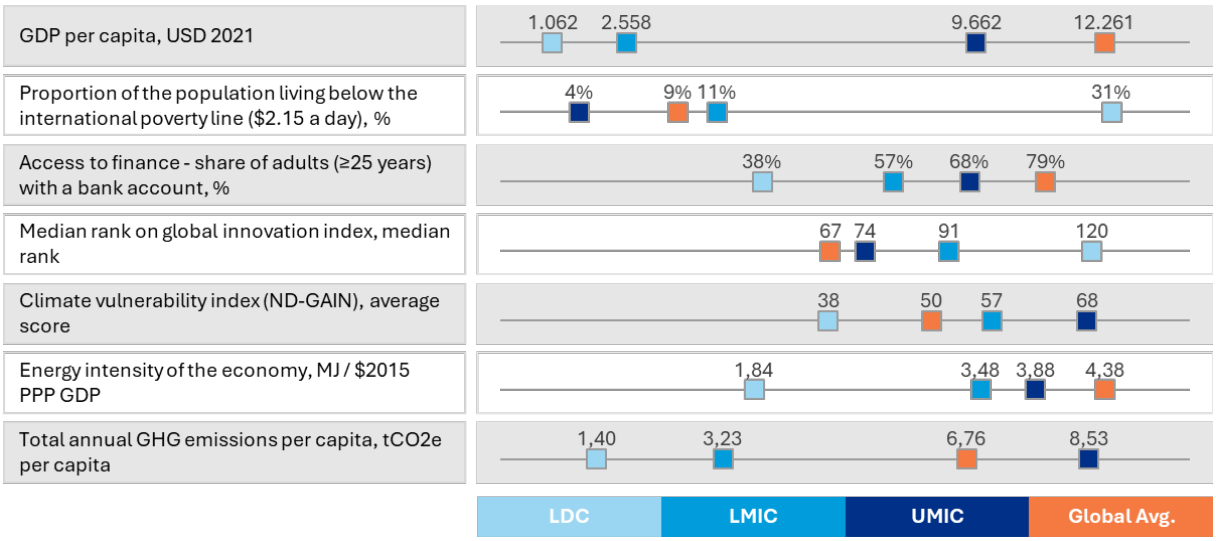


Figure 2: ODA Recipient Countries in Global Comparison

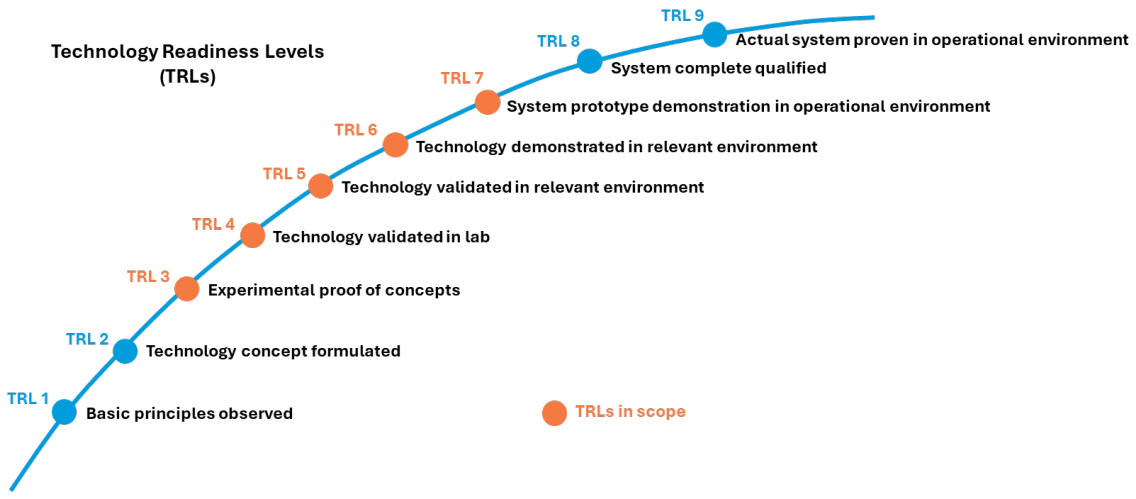


As "access to finance" is lower across ODA recipients in all income-level groups and poorer countries rank lower on the "global innovation index", the need for support and funding to promote technology innovation is the highest where income levels are the lowest.

A2D's purpose is to accelerate and catalyze the benefits of innovative technologies which can help developing countries to become more prosperous in the global market while limiting the impact on climate change. The facility concentrates on four thematic areas pivotal for clean industrial development: critical minerals, clean hydrogen, smart energy and industrial decarbonization. The focus lies on supporting innovative technologies which have successfully passed the early conceptual stages of development, i.e. technology readiness levels (TRL) 1 to 3, and which have already progressed to the validation and demonstration stages (TRL 4 to 7).

This document presents the results of two comprehensive market assessments of the technology innovation landscapes and environments related to smart energy and industrial decarbonization (i.e., two of the four A2D thematic focus areas) in developing country contexts.

Figure 3: Technology Readiness Levels



2.2. Market assessments

Solutions in both smart energy and industrial decarbonization are pivotal for addressing global climate challenges and enabling sustainable economic development. New technologies and their applications have the potential to reduce GHG-emissions by replacing emission-intensive energy sources with cleaner ones and enhancing efficiency.

SE

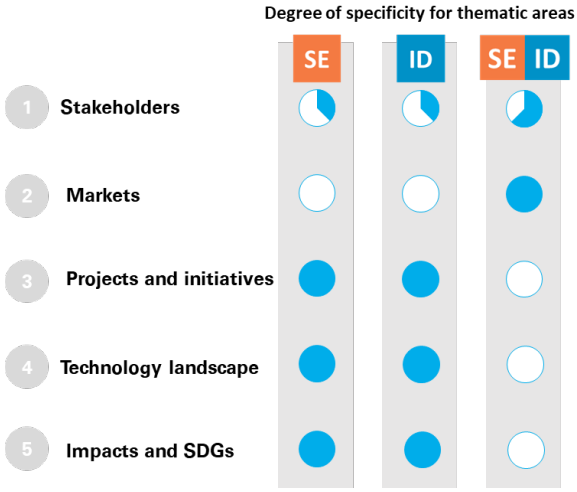
Smart energy (SE) refers to data-driven technologies and solutions which enable an efficient and effective supply and usage of energy. These exploit digital technologies, Artificial Intelligence (AI) or the Internet of Things (IoT) to provide solutions such as smart grids, smart devices, decentralized energy systems (DES), blockchain-enabled data management, remote monitoring and controls, and demand-side response (DSR) tools. In developing countries significant parts of the population do not have access to electricity and affordability of energy is a primary concern for the competitiveness of businesses in local and global markets. SE technologies can provide energy access accelerate clean energy transitions and drive economic growth while addressing environmental challenges.

ID

Industrial decarbonization (ID) refers to the strategic reduction or elimination of carbon dioxide (CO2) and other greenhouse gas (GHG) emissions from industrial production. This can be achieved by switching to low-carbon energy sources, adopting cleaner production methods, and improving energy efficiency. Decarbonization can be materialized at the level of source, process, and cycle. Since carbon-intensive heavy industries like steel, chemicals and cement, represent core pillars of the economic model of many developing countries, the promotion of innovative technologies, such as Carbon Capture, Usage and Storage (CCUS) are particularly important for developing countries with rapid economic growth.

While SE and ID represent two distinct thematic areas, there are significant overlaps and cross-cutting themes, especially with regards to the enabling environments and types of market constraints affecting the successful adoption and scaling of innovative technologies in the countries in scope. The results in this document reflect both the specificities and the cross-cutting themes related to technology innovation in SE and ID in developing countries. The **five core areas of analysis** – 1) stakeholders, 2) markets, 3) projects and initiatives, 4) technology landscape, 5) impacts and SDGs – show different degrees of overlap.

Figure 4: Degree of thematic-area specificity



Significant common ground exists with regards to relevant stakeholders and markets. These two areas of analysis provide the enabling environment which determine the suitability of markets for investment in technology development projects. These factors encompass a wide range of parameters, including economic, demographic, political, social, and environmental aspects. They also include the maturity of the policy landscape and the commitment to enact governmental strategies to reduce emissions.

A key differentiating factor between SE and ID is the set of technologies that fall under the respective thematic areas. With some exceptions (especially related to energy efficiency enhancing solutions) the sets of key technologies and solutions differ. Consequently, the landscapes of projects and initiatives advancing these technologies also differ. The market assessment also evaluates how the SDGs – in particular SDG 1 (No

Poverty), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action) – are promoted through relevant SE- and ID-specific technologies. Hence, this core area of analysis also provides distinct results. Therefore, this document provides the results of two market assessments for two of the A2D Facility's thematic areas, SE and ID, with common results in two of the core areas of analysis, i.e., stakeholders and markets.

The primary objective of the market assessments is to provide reliable and relevant information that enable UNIDO and UK DESNZ to identify high-potential markets, technologies, and projects most relevant in the context of accelerating, scaling, and commercializing innovative clean energy technologies in developing countries. A curated project pipeline provides examples of "lighthouse" projects which can serve as models for emulation.

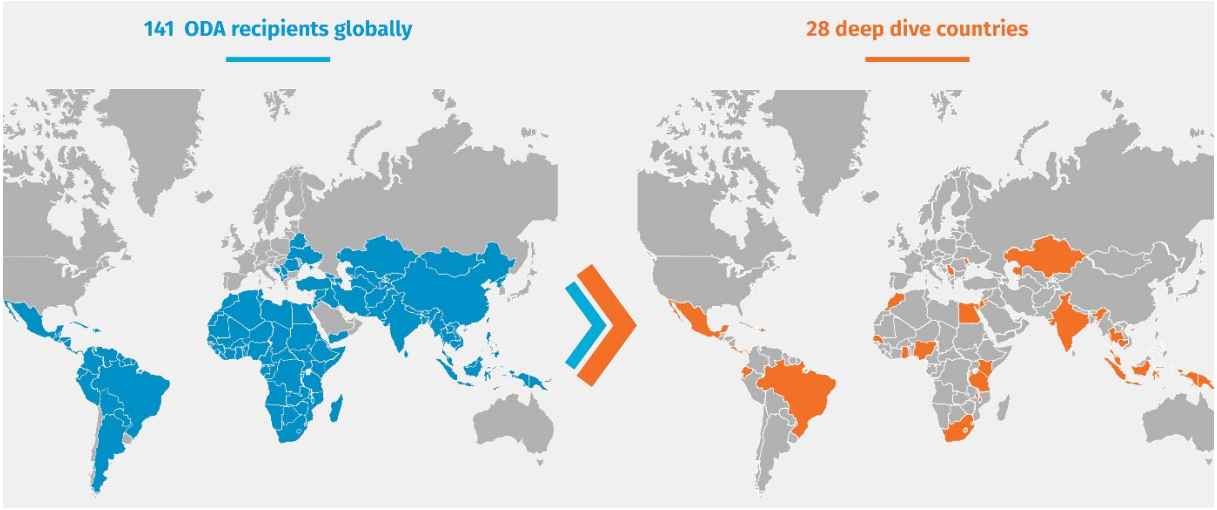
3. Delineation of assessment scope

3.1. Countries in scope for assessments

While the assessments provide a global view covering all **141 ODA recipient countries, a representative and highly relevant set of 28 countries has been selected for deep dive analysis**. These deep dives countries have been found to serve as promising environments for advancing and leveraging innovative technology solutions in smart energy and industrial decarbonization. They also serve as a basis for identifying relevant existing and planned projects.

More than 50% of ODA recipient countries are in Africa and Asia, with Asian countries alone accounting for ~67% of the population in the developing world, and ~55% globally. The selection of deep dive countries involved a nuanced approach based on performance-based selection (including exclusion criteria) as well as regional, sub-regional and income-level representation. (For additional details on the country selection see chapter 5 “Methodology and Data collection”.

Figure 5: Overview of focus countries



Africa	Asia	Americas
1. Malawi	13. Cambodia	22. Domin. Republic
2. Rwanda	14. India	23. Costa Rica
3. Tanzania	15. Jordan	24. Mexico
4. Senegal	16. Kazakhstan	25. Panama
5. The Gambia	17. Indonesia	26. Brazil
6. Kenya	18. Malaysia	27. Ecuador
7. Egypt	19. Thailand	
8. Morocco		
9. Ghana	**Europe**	**Oceania**
10. Nigeria	20. Moldova	28. Papua New Guinea
11. Mauritius	21. Serbia	
12. South Africa		

3.2. Focus industries in selected countries

SE and ID are critical for a wide range of sectors. **Nine key industries** have a distinctly high relevance for many ODA recipient countries, and hence provide the focus of analysis. They include aluminum, iron and steel, metallic products, chemicals and plastics, cement and concrete, power and utilities, pulp and paper, textile, and transport. These industries have been identified based on three main criteria: 1) the sector's contribution to global GHG-emissions, 2) the availability of suitable technologies within the TRL 3 to 7 range, and 3) their relevance for ODA countries, especially for the 28 focus countries.

Smart energy solutions transcend sectoral boundaries. They are not confined to any industry because their primary focus is on optimizing energy use and the integration of renewable energy sources. Smart energy technologies, such as smart grids, energy management systems, demand response, and advanced metering infrastructure can be applied to any system or process that uses energy or electricity – whether in residential buildings, commercial facilities, transportation, or industrial operations.

In contrast, **industrial decarbonization** is many cases inherently sector-specific because it targets the reduction of GHG-emissions within specific industries. Each industry has unique processes, technologies, and energy requirements. Therefore, decarbonization strategies need to be tailored to the specific needs and characteristics of each sector. This sectoral approach allows for more targeted interventions, such as process optimization, fuel switching, or CCUS, which are critical for achieving deep emissions reductions in industries that are traditionally hard to decarbonize.

Figure 6: Overview of focus industries

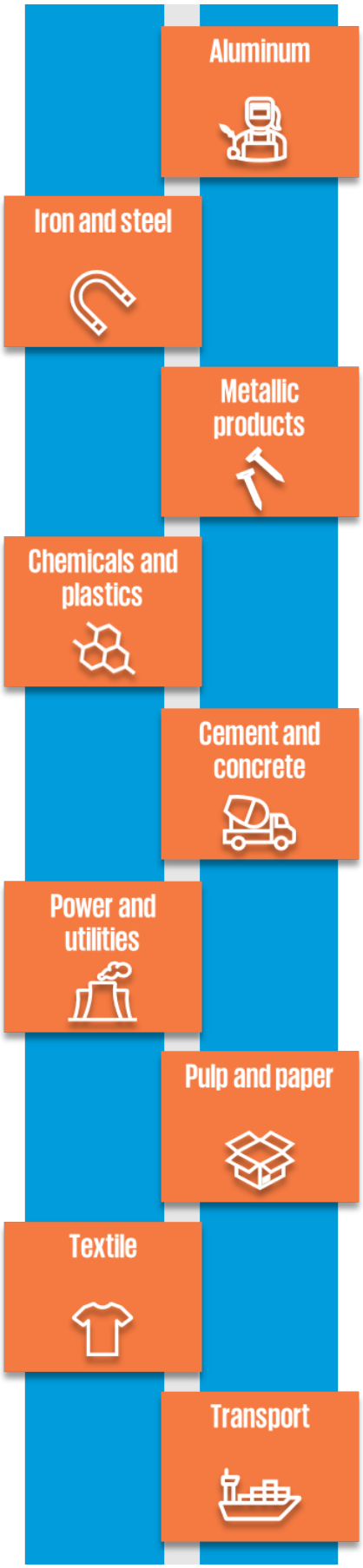
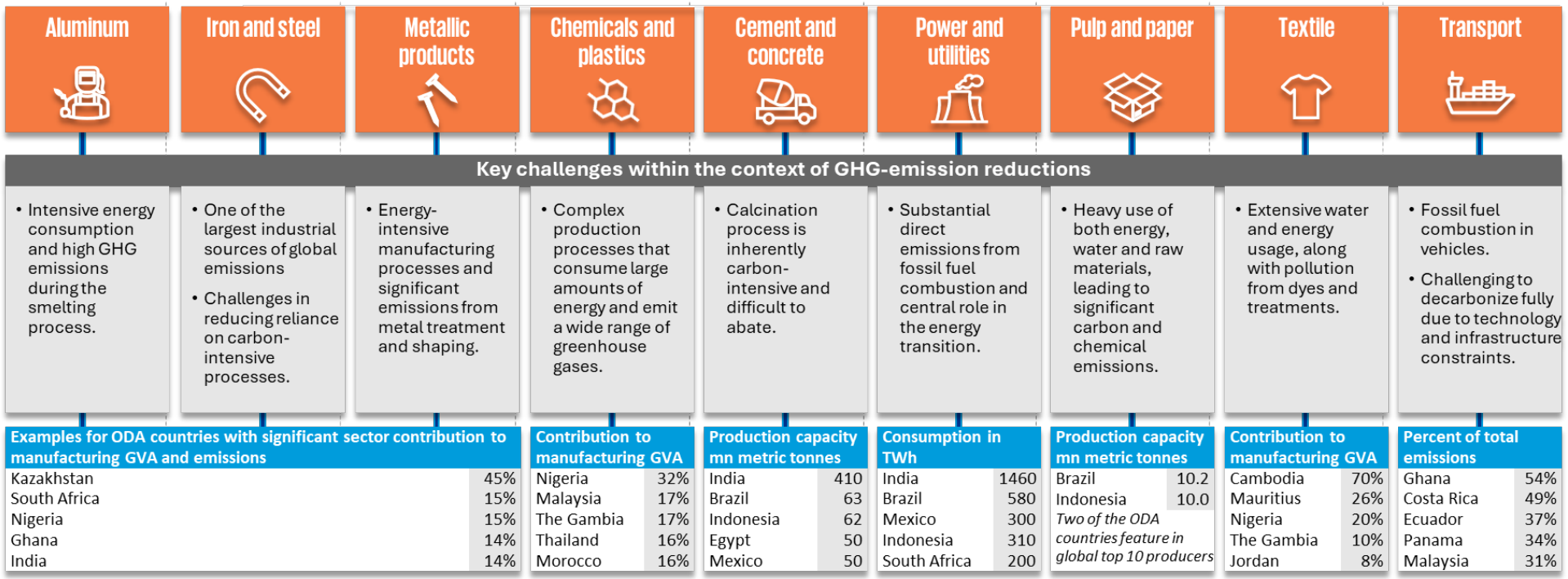


Figure 7: *Identification of focus industries*

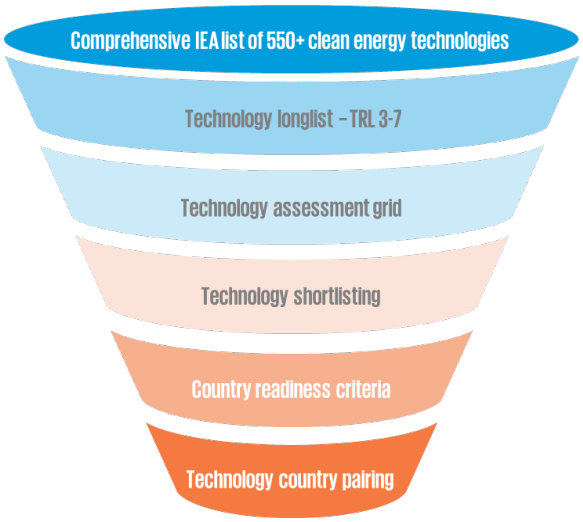
The industry selection was based on the sector's contribution to global GHG-emissions, availability of suitable technologies within the TRL 3-7 range and their relevance for ODA countries, especially for the 28 focus countries (percentages indicate share of gross value added by the sector to the country's manufacturing GVA or overall GDP).



3.3. Key technologies for smart energy and industrial decarbonization

An initial longlist of 550+ clean energy technologies provided by the International Energy Agency (IEA) served as the starting point for both thematic areas. From this list those in the TRL range 3 to 7 were selected.

Figure 8: *Identification of key technologies*



In a next step the selected technologies were assessed across key attributes such as affordability, technical feasibility, scalability, potential impact, and degree of innovation using a bespoke assessment grid. Technologies were shortlisted based on their score and relevance for SE and ID respectively. The shortlisted technologies were further assessed against country readiness criteria which encompass enabling factors such as innovation readiness, macro and demographics, and industry focus. In this way the aptness of different technologies was analyzed in the context of the maturity of different markets. Finally, focus technologies were identified for each deep dive country based on technology attributes and respective country requirements. The comprehensive results are presented in in chapter 4 of this document. A summary of key technology groups for SE and ID respectively is provided below.

SE

Smart energy technology groups include (non-exhaustive list):

- Incorporation of renewable energy sources
- Smart electricity systems
- Smart grid technologies
- Incorporation of AI / Big Data
- Digital solutions in support of electric mobility
- Smart thermal systems
- Energy efficiency measures
- Smart energy storage and management

ID

Industrial decarbonization technology groups include (non-exhaustive list):

- Electrification
- Change in feedstock or fuel
- Process optimization
- Energy efficiency improvements
- Material efficiency and circular economy
- Carbon capture, use, and storage (CCUS)
- Supply chain optimization.

4. Results

The assessments focus on **five core areas of analysis** which are addressed by providing answers to **eleven predefined research questions** for both SE and ID (see details below).

While the technology and project landscapes are distinctive for each thematic area, cross-cutting topics such as macroeconomic data, policy and regulatory environments, or local infrastructure are more or less of equal importance for both SE and ID. Hence, the first two analytical areas, stakeholders, and markets, exhibit significant commonalities between the two thematic areas and are treated as "cross-cutting themes".

The results of the market assessments are provided in the following form:

- Answers to eleven research questions consisting of three components: 1) cross-cutting themes, 2) SE-specific, and 3) ID-specific information.
- Analysis of 28 selected deep dive countries.

Thematic-area specific information is marked with an "SE" and "ID" icon respectively. Common or cross-cutting topics are marked with both logos.

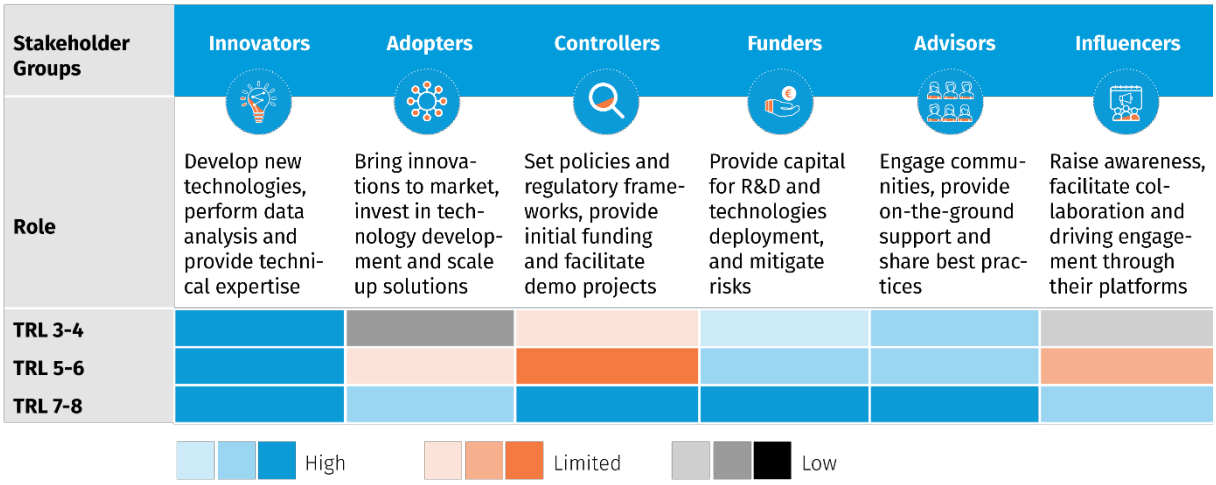
Area of analyis	#	Research Questions
Stakeholders (cross-cutting themes)	Q1	**Landscape of stakeholders:** who are the key stakeholders in technology innovation in SE / ID in developing country contexts and how important are they in moving projects from early planning and analytical products to pilot demonstrations?
	Q2	**Landscape of innovators and adopters:** what is the landscape of innovators and adopters working on SE / ID in developing country contexts?
	Q3	**Landscape of beneficiaries:** who are the main beneficiaries of support from projects focused on innovation in SE / ID in developing country context?
Markets (cross-cutting themes)	Q4	**Landscape of countries:** which developing countries have policy frameworks and regulatory environments relating to technology innovation in SE / ID ? Which developing countries have the most demand or potential for support for technology innovation?
	Q5	**Landscape of additionality:** where would an intervention in innovative clean energy technologies for SE / ID have the most transformational impacts and be most additional in the current policy landscape and countries' national strategies?
	Q6	**Landscape of market constraints:** what are the primary market constraints for technology innovation in SE / ID in developing country contexts?
Projects and initiatives	Q7	**Landscape of initiatives:** what are the key existing and planned initiatives, partnerships and collaborations that include an innovation focus in SE / ID in developing country contexts, what are the activities-of-focus, in which countries and how are they funded?
	Q8	**Landscape of projects:** what are existing and planned programs, projects and work streams that focus on innovation in SE / ID in developing country contexts, what are the activities-of-focus, in which countries and how are they funded?
	Q9	**Project pipeline:** what is the potential portfolio of lighthouse pilot projects for technology innovation in SE / ID in developing country contexts?
Technologies	Q10	**Landscape of technologies:** to what extent are current innovative clean energy technologies in SE / ID applied to developing country contexts in TRL 3-7?
SDG and impacts	Q11	**SDG assessments:** what is the evidence-based theories of change for supporting technology innovation in SE / ID in developing country contexts against the most relevant SDGs?

4.1. Landscape of stakeholders

#01 Who are the key stakeholders in technology innovation in smart energy in developing country contexts and how important are they in moving projects from early planning and analytical products to pilot demonstrations?

SE ID The analysis revealed six critical stakeholder groups crucial for technology innovation in both SE and ID: 1) innovators, 2) adopters, 3) controllers, 4) funders, 5) advisors, 6) influencers. Each group contributes uniquely across various stages of the TRL spectrum.

Figure 9: *Stakeholder groups´ level of involvement by TRL*



Innovators are central to the development and refinement of new technologies. This group includes think tanks, academic institutions, research organizations, startups, tech companies, corporate R&D units, and manufacturing associations. At TRL 3-4, innovators and advisors play a significant role in technology development. Data from interviews and analysis indicate that tech companies and corporate R&D are particularly pivotal at this stage, with startups also being crucial (this was supported by almost one third of a experts interviewed for this market assessment – see appendix).

Adopters are essential for bringing innovations to market and scaling solutions. They encompass end users, SMEs, large users, service companies, product manufacturers, and the private sector. As technologies progress to TRL 5-6, the involvement of adopters and controllers becomes more pronounced. Almost 80% of experts interviewed observed increased engagement of these stakeholders at these stages, reflecting their critical role in integrating and scaling technologies.

Controllers are responsible for setting policies, regulatory frameworks, and facilitating initial funding for demonstration projects. This group includes government bodies, regulatory agencies, certification bodies, utilities, network operators, and local authorities. By TRL 7, controllers are crucial for ensuring compliance and supporting large-scale demonstrations. Notably, one third of experts interviewed for the market assessments[1] highlighted the importance of development banks and bilateral donors in providing substantial funding at this stage.

Funders provide capital for research, development, and technology deployment while mitigating financial risks. This group comprises banks, donors, financial institutions, private finance sources, and investment funds. Their role is especially important at TRL 3-4, where they supply the

[1] 28 experts were interviewed as part of the market assessments. Further details are included in chapter 5 "methodology and data collection".

initial financial support required to advance technologies from research to early development stages.

Advisors engage with communities, provide support, and share best practices. This group includes NGOs, energy and industrial associations, and consultants. Advisors are crucial in supporting technology development and deployment, particularly through community engagement and practical guidance.

Influencers raise awareness and foster collaboration through their platforms. This group consists of media, social media influencers, associations, and ministers. By TRL 7, their role in raising awareness and facilitating collaboration becomes significant, aiding in the broader adoption of technologies.

These findings underscore the evolving importance and involvement of these stakeholder groups as technologies progress through different TRL stages. Innovators and advisors are prominent in earlier stages, while adopters, controllers, and funders become more critical as technologies mature and scale.

4.2. Landscape of innovators and adopters

#02 What is the landscape of innovators and adopters working on smart energy / industrial decarbonization in developing country contexts?

SE ID In the evolving landscape of SE and ID technologies and solutions, understanding the roles and contributions of innovators and adopters sheds light on the dynamics driving the advancement of technology development and adoption.

Innovators are crucial in developing and refining technologies that cater to local energy needs and can be scaled cost-effectively. They include various types of actors such as academic institutions, research organizations, startups, tech companies, corporate R&D departments, and manufacturing associations.

Examples include:

Academia: The University of Dar es Salaam (UDSM) in Tanzania, through its Igrid Project, is a key player in the development of smart energy solutions tailored to local requirements.

Startups: Startups in Cambodia, supported by the Global Cleantech Innovation Program (GCIP), are spearheading innovations in clean technologies.

Corporate R&D: In Malaysia, TM R&D collaborates, the innovation hub of the stock listed Telekom Malaysia group, with Air Selangor on smart water management. Hitachi ABB's Jakarta Green Mining Microgrid Project in Indonesia and South Africa's Solar MD's Evolve Virtual Power Plant exemplify how corporate R&D makes significant contributions to scaling and improving technology solutions.

These innovators not only develop and pilot new technologies but also inform policy and investment strategies through evidence-based research.

Adopters also drive scaling and improvement of new technologies by implementing and applying them in specific contexts. They seek user-friendly and economically viable solutions that offer good RoI and enable exploitation of efficiency potentials. Moreover, they contribute directly (e.g., through project involvement) or indirectly (e.g., through consumption) to the development of new technologies.

Examples of direct engagement include:

End users: Participation of residents in Brazil's Demand-Driven Electricity Networks Initiative (3DEN).

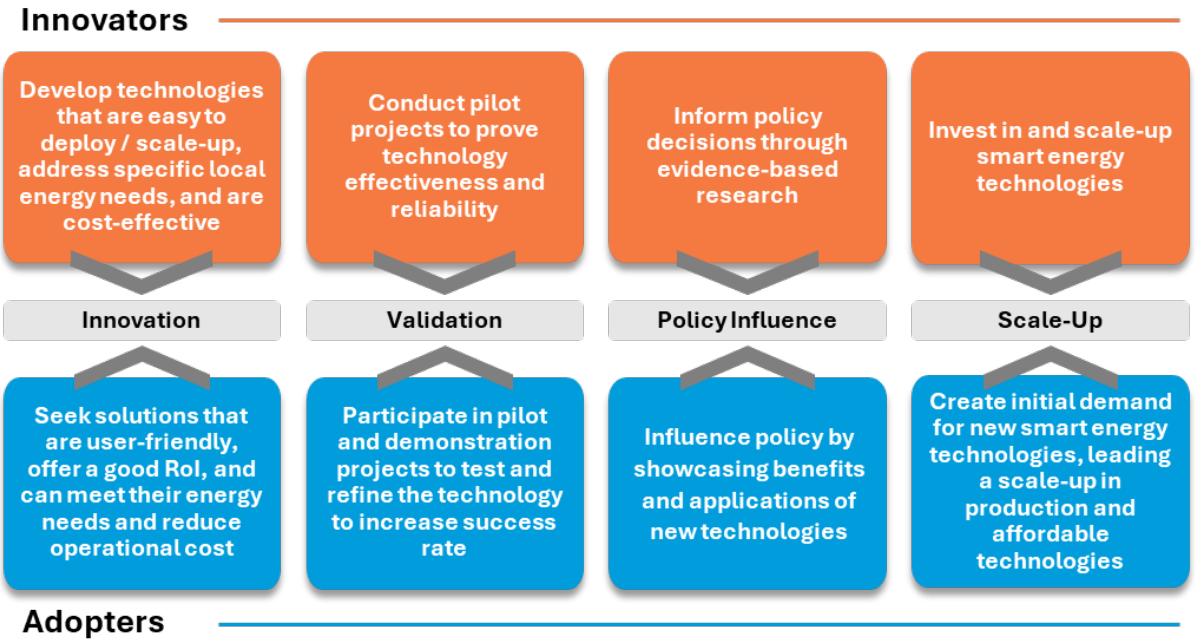
Service companies: Air Selangor, Malaysia's largest water services provider, has a roadmap and actively engages in projects promoting digitalization of the water industry (e.g., through automation of operations and Big Data analytics).

These adopters participate in pilot and demonstration projects to validate technologies, influence policy by showcasing benefits, and create initial demand, which boosts RoI for the innovators and positively

affects the affordability of new technologies through accelerated scaling.

The relationship between innovators and adopters in the development of innovative technology solutions are characterized by collaboration. Innovators and adopters work together to advance technologies, supported by controllers (government bodies), advisors (NGOs), and funders (financial institutions). Public-private-partnerships (PPPs) can be particularly effective in scaling smart energy solutions which involve decentralized energy systems since they can help bridge the gap between governmental entities running central infrastructure, private firms and local communities.

Figure 10: Innovators & Adopters: Interlocking of core tasks and roles across the innovation process



4.3. Landscape of beneficiaries

#03 Who are the main beneficiaries of support from projects focused on innovation in smart energy/industrial decarbonization in developing country contexts?

The exploration of who benefits from projects centered on smart energy and industrial decarbonization innovation in developing countries is pivotal for optimizing future initiatives. By identifying and analyzing these beneficiaries, it becomes possible to tailor projects to maximize positive outcomes and effectively support vulnerable populations.

SE Understanding impacts of these projects reveals that the primary beneficiaries are adopters and controllers. Adopters, such as **local communities** and **households**, experience significant improvements in their access to and affordability of energy. A recent market assessment highlights that advancements in decentralized renewable energy generation and reduced costs have been crucial in enhancing global electrification efforts, particularly in regions where electricity access has previously been limited.

For example, smart energy solutions significantly improve living standards in rural and urban areas by addressing energy scarcity, which disproportionately affects **women** and can empower them economically by reducing their workload. **Public services**, including education and healthcare, also benefit from a reliable energy supply, as it enables better learning environments and more comprehensive healthcare services. Additionally, SMEs that adopt these technologies often achieve cost reductions and operational efficiencies, enhancing their competitive-ness and growth potential.

Controllers, encompassing **local authorities** and **governments**, also derive substantial benefits from these projects. Enhanced energy solutions improve public services, street lighting, and other community infrastructure. Governments investing in smart energy innovations can mitigate their economic exposure to volatile oil prices and the decline of fossil fuel markets, thus enhancing energy security and resilience. Furthermore, these projects often attract foreign investment and create new job opportunities, stimulating local economic growth and development.

In addition to adopters and controllers, other stakeholders also benefit in distinct ways. Innovators gain access to new markets and customers, diversifying their revenue streams. Funders achieve a higher return on investment (RoI), diversify their portfolios, and align with Sustainable Development Goals (SDGs), contributing to the economic development of emerging markets. Advisors influence policy, fulfill Environmental, Social, and Governance (ESG) missions, and build robust partnerships. Influencers report on success stories, enhance their industry influence, educate the public on smart energy benefits, and gain insights into market trends.

ID Similar results can be seen when looking at the impacts of industrial decarbonization projects, where adopters and controllers stand out as the main beneficiaries.

Adopters, including **local communities** and **workers** in industrial areas, stand to gain significantly from reduced pollution and lower health risks. Cleaner industrial practices lead to improved air and water quality and involve the use of fewer hazardous chemicals, thereby enhancing the overall living and working conditions. Large users, who consume substantial amounts of energy and have significant carbon footprints, also benefit greatly.

The adoption of new technologies can result in considerable emissions reductions, helping these users meet regulatory and corporate sustainability goals. Additionally, advanced technologies can improve operational efficiency, leading to cost savings and increased productivity. For large users, maintaining a positive public image is crucial, and adopting sustainable technologies can enhance their reputation and foster better stakeholder relations.

Small and medium-sized enterprises (SMEs) are another group of main beneficiaries. Often lacking the resources to develop new technologies independently, SMEs can access cutting-edge solutions through support from

decarbonization projects. This support improves their competitiveness by enabling cost savings and enhanced product offerings. By becoming early adopters of sustainable technologies, SMEs can differentiate themselves in the market, attracting environmentally conscious customers and investors.

Controllers, such as governments, also reap significant benefits. Decarbonization projects help **governments** meet national and international climate targets, such as those set by the Paris Agreement. These projects can stimulate economic growth by creating new industries and job opportunities, leading to higher tax revenues and improved public welfare. Promoting energy efficiency and renewable energy sources enhances national energy security by reducing dependence on imported fossil fuels. Additionally, reducing industrial emissions improves air quality, leading to better public health outcomes and reduced healthcare costs. Successfully implementing decarbonization projects can enhance a country's global standing and attract foreign investment.

Other stakeholder groups also benefit from industrial decarbonization. Innovators receive funding and resources to develop and refine new technologies, leading to commercialization opportunities and industry recognition. Adopters achieve significant cost savings, improved operational efficiency, and compliance with environmental regulations through the adoption of advanced technologies. Controllers meet climate targets, enhance energy security, and improve public health outcomes by supporting decarbonization initiatives. Funders find new investment opportunities with the potential for high returns on investment (RoI) and fulfill sustainability mandates, thereby enhancing their corporate social responsibility profiles. Advisors enhance their influence and effectiveness by engaging in impactful projects, promoting sustainable development, and providing expertise. Influencers increase their reach and impact by raising awareness about sustainability and industrial decarbonization, thereby enhancing their public profiles and credibility.

Key Takeaways – Stakeholders

Technology development is shaped by **six different key stakeholder groups** which influence the development process to varying degrees at different stages.

Innovators and adopters play a particularly critical role for technology development in both SE and ID. The dynamic between them is marked by a collaborative relationship.

Adopters, together with controllers, also emerge as the **main beneficiaries** in developing countries. In many developing countries (as elsewhere) controllers tend to have a very limited level of engagement in the early stages (TRL 3-4) which becomes quite significant as technology development progresses.

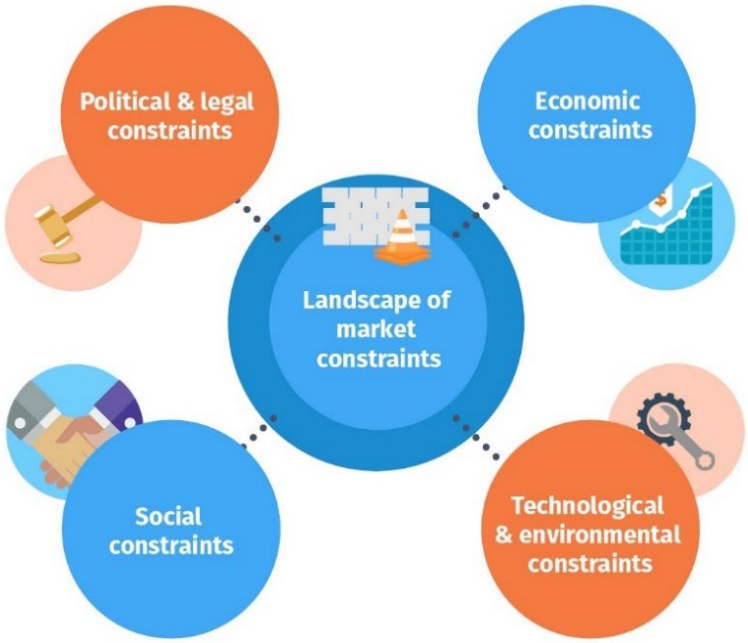
4.4. Landscape of market constraints

#04 What are the primary market constraints for technology innovation in smart energy / industrial decarbonization in developing country contexts?

SE ID In developing countries, the adoption of technology innovation in both SE and ID faces numerous market constraints that span political, legal, economic, social, technological, and environmental domains.

These constraints are often interconnected, and they impede the introduction, scaling, and long-term viability of innovative solutions much needed for the reduction of carbon emissions.

Figure 11: Landscape of market constraints



Political and legal constraints are among the most significant impediments to progress in both SE and ID. Corruption and fraud, prevalent in many developing countries, deter investment as they create significant risk costs. Moreover, successful implementation and management of resource-intensive projects becomes highly unlikely. Poorly developed and patchy regulatory and policy environments present major obstacles for investors and adopters as they are exposed to a high degree of uncertainty. Very strict regulatory environments and high levels of bureaucracy, on the other hand, can delay project approvals, and thus impede private sector investment, and create reluctance among companies to adopt innovative technologies due to regulatory compliance costs.

Generally, though a lack of supportive policies—such as incentives for low-carbon technologies or a cohesive framework to encourage decarbonization—limits the market's potential to attract private sector investment. Additionally, political instability or uncertainty about future regulations and policies further dampens investor confidence, exacerbating the risks associated with long-term investment in clean technologies. Regions pursuing green steel or bioenergy projects, can be strongly affected by a lack of clear policy incentives and insufficient pricing and taxation mechanisms. In Brazil, for example, the adoption of bioenergy with carbon capture and storage (BECCS) technologies has been slowed down by regulatory delays, such as the postponement of the "Fuel of the Future" bill, which is critical to securing the necessary legal backing for the project.

Economic constraints are amongst the most common and fundamental challenges. Large-scale projects require substantial investment. The limited availability of different investment mechanisms—such as green bonds or private sector engagement—makes

it difficult for many developing countries to fund necessary projects. Financial instability, including currency devaluation make financial environments unpredictable and hence unattractive for large-scale investment. Many smart energy projects depend on foreign equipment and expertise, requiring transactions in foreign currencies, which creates additional financial risks when local currency values fluctuate.

Industrial decarbonization is particularly affected by financial constraints, since key technologies such as green steel production or CCUS are very cost intensive. High initial investment costs, coupled with the lack of concessional funding mechanisms, make it difficult for developing countries to deploy these technologies at scale. The costs for replacing incumbent technologies and production processes are regarded as a threat to the competitiveness of existing businesses, especially in industries which are under significant pressure, such as steel. Hence, limited financial support available for large-scale projects in the steel and bioenergy industries in many cases implies that planned projects are not implemented or completed (examples include India's green hydrogen steel pilot projects and Brazil's bioethanol biorefinery complex).

Market structures also play a critical role. Energy markets in developing countries are often dominated by a few large corporations, which limits competition and reduces the incentive to innovate. This lack of competition can stifle the adoption of new technologies and prevent market structures from evolving in a way that supports large-scale deployment of SE and ID solutions.

Social and cultural constraints can manifest in various forms, such as a resistance to change in corporate environments and production sites, limited consumer awareness, and a lack of technical expertise. Cultural resistance to adopting new technologies, especially those requiring significant behavioral shifts or operational changes, is a common problem. This can be exacerbated by a general lack of awareness among consumers and policymakers about the benefits of new technologies, leading to limited demand and delays in the implementation of innovative solutions.

The lack of skilled labor and technical expertise, particularly in rural or underserved areas, creates a significant barrier to the successful deployment and maintenance of technologies such as microgrids or digital twin systems. Issues resulting from skills-gaps might be entrenched when adequate capacity-building programs are missing. Positive examples, such as Tanzania's iGrid project in which the challenge of local expertise was addressed through a collaborative platform designed to share knowledge and foster innovation among local stakeholders and international experts, provide good practices to be emulated. In the context of ID, social constraints are particularly evident in the case of green hydrogen and green steel projects. The immaturity of the market for green hydrogen and the lack of demand for green steel makes it difficult to create the necessary momentum for widespread adoption. Notable exceptions are India's green hydrogen steel pilot projects, which aim to encourage participation in global low-carbon steel markets and to create demand for these technologies.

Technological and environmental constraints are closely linked to infrastructure limitations, geographical factors, and the maturity of the technology. A lack of modern infrastructure — such as grid capacity, digital infrastructure, or storage facilities — in many developing countries poses a significant challenge for the adoption of innovative SE and ID technologies. In the context of SE solutions, limited access to advanced infrastructure prevents the scaling of technologies such as renewable energy systems, while the lack of coordination among research institutions hampers the development and deployment of cutting-edge technologies. ID tends to be affected even more profoundly by missing or outdated infrastructure. For example, the adoption of green hydrogen in the steel industry in India is constrained by the absence of sufficient production, distribution, and storage infrastructure. The geographical and environmental characteristics of developing countries also create additional challenges, such as the need for resilient energy systems capable of withstanding extreme weather events or natural disasters. These constraints

can slow the transition to cleaner energy sources, as energy stability often takes precedence over the adoption of new technologies. In some cases, innovative strategies have been implemented to address these constraints. For instance, in Brazil's FS bioethanol project, geological studies were conducted to identify suitable sites for the underground storage of CO2, demonstrating a successful approach to overcoming environmental challenges related to carbon capture and storage.

4.5. Landscape of countries

#05 Which developing countries have policy frameworks and regulatory environments relating to technology innovation in smart energy / industrial decarbonization? Which developing countries have the most demand or potential for support for technology innovation?

SE ID Governments around the world are increasingly aware of the pivotal role of supportive policy structures in facilitating the adoption of innovative technologies and achieving ambitious energy and climate goals. Across the developing world, countries with progressive policies and regulatory environments provide valuable case studies for understanding how innovation in SE and ID can be effectively supported. The market assessments identified countries that have not only established comprehensive policy frameworks but have also created stable regulatory conditions conducive to innovative technologies. As emerging economies often face challenges in balancing economic development with environmental sustainability, the establishment of effective and well-designed policy frameworks becomes highly important.

A comprehensive review of relevant policies across the focus countries reveals that **India, Brazil, Thailand, South Africa, and Mexico have established leading frameworks for SE and ID**. Each country offers valuable examples of policies designed to foster technological innovation for the purpose of meeting climate-goals, reducing emissions and paving the way for clean transitions. A common feature of relevant policies across the countries in scope is that there are many policies and plans addressing clean energy transitions and industrial decarbonization, yet the vast majority does not specifically relate to technology innovation in SE or ID. Moreover, most policies do not distinctly address SE or ID specific themes. However, some of the policies' content is more relevant to one of the thematic areas than the other.

SE **India** has developed a comprehensive approach to integrating renewable energy, promoting energy efficiency, and advancing sustainable urban development. Through initiatives such as the National Smart Grid Mission and the Smart Cities Mission, the Indian government has created a policy environment that encourages innovation in smart energy management systems, infrastructure development, and technology deployment. This effort is complemented by its ambitious renewable energy targets, which have driven a rapid increase in solar and wind energy capacities.

Similarly, **Thailand's** Smart Grid Master Plan (2015 – 2036) provides a long-term vision for integrating smart grid technologies to enhance the efficiency and reliability of its energy systems, promoting renewable energy integration and reducing emissions. The country has also capitalized on its strategic role as a regional hub in Southeast Asia to attract international investments in smart grid technologies, a factor that has been critical for scaling technological adoption.

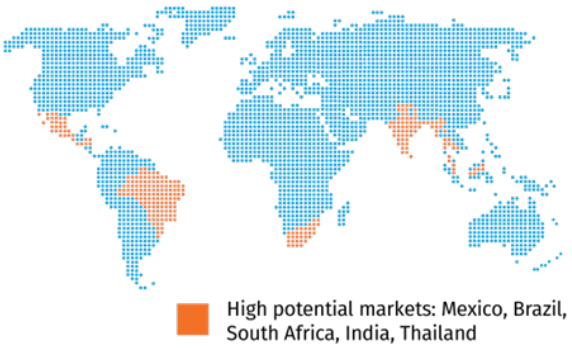
Mexico has developed policies such as the Smart Grid Implementation Plan which promotes the adoption of smart energy solutions. With a focus on grid modernization, Mexico advances the deployment of smart grid technologies that improve the reliability and integration of renewable energy sources.

Similarly, **Brazil** has developed a focus on smart grids. There have been substantial investments (USD 36.6 billion in 2022) in smart grid technology and a supportive

regulatory framework (e.g., National Energy Plan) is in place. Moreover, Brazil leverages public-private partnerships to support the large-scale deployment of these technologies, a strategy that has allowed for greater technological diffusion across different regions of the country.

These countries, while facing distinct challenges, offer examples of successful policy implementation, where strong regulatory frameworks support the deployment of smart energy technologies. A common theme is the emphasis on grid modernization, energy efficiency, and renewable energy integration. Advanced metering infrastructure, smart grids, and energy storage solutions are key technologies promoted through these policies, enabling more efficient and reliable energy systems.

Figure 12: *Country examples with leading frameworks for smart energy*



Brazil

- Brazil has been actively working on smart grid deployment to modernize its electricity infrastructures like transportation, buildings, and public services
- Brazil's smart grid investments are projected to reach $36.6 billion by 2022 and includes regulatory and financial support from USDA, utility level initiatives like Copel in Parana which aims to aim to automate distribution networks and improve overall efficiency

Mexico

- Mexico's policy frameworks for smart energy focus on increasing renewable energy adoption and enhancing energy efficiency
- The country is also advancing smart grid technologies to improve grid reliability, efficiency, and integration of renewable energy. These efforts are supported by the Smart Grid Implementation Plan, which addresses regulatory, technical, and consumer challenges

South Africa

- South Africa's policy frameworks for smart energy focus on transitioning to a more sustainable and resilient energy system
- The country is also advancing smart grid technologies to enhance grid reliability, efficiency, and integration of renewable energy. These efforts are supported by the South African Smart Grid Initiative (SASGI), which addresses regulatory, technical, and consumer challenges

India

- India's policy frameworks for smart energy focus on integrating renewable energy sources, enhancing energy efficiency, and promoting sustainable urban development.
- Key initiatives include the Smart Cities Mission, National Smart Grid Mission, which aims to incorporate smart energy management (SEM) principles across various sectors like transportation, buildings, and public services

Thailand

- Thailand's policy frameworks for smart energy focus on increasing renewable energy adoption and enhancing energy efficiency
- The country is also advancing smart grid technologies to improve grid reliability, efficiency, and integration of renewable energy. These efforts are supported by the Smart Grid Master Plan (2015-2036), which outlines deployment of smart grid projects and pilot programs across various regions

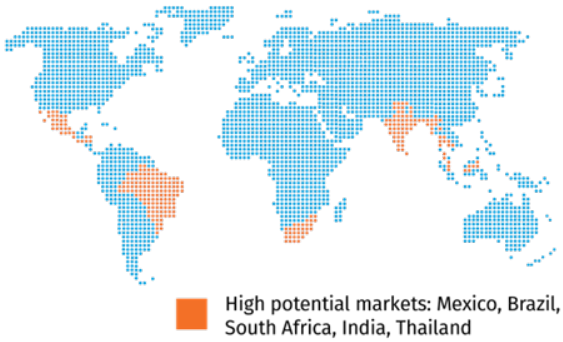
In the context of ID, India, Brazil, and South Africa have adopted sector-specific roadmaps and overarching national policies.

ID In **India**, decarbonization efforts are focused on hard-to-abate sectors such as steel and cement, with policies aimed at promoting energy efficiency and the adoption of low-carbon technologies such as hydrogen and CCS / CCUS. The Green Hydrogen Mission and the Perform, Achieve and Trade Scheme are central to these efforts, offering financial and regulatory incentives to industries to transition towards greener production processes.

Similar efforts can be seen in **Brazil** where sector-specific policies have been developed to decarbonize key industries such as steel, cement and petrochemicals. The country has, for example, adopted a new industrial policy (Nova Indústria Brasil) in 2024 which aims, amongst others, at the digitization and decarbonization of core industries. The Industrial Deep Decarbonization Initiative includes sector-specific roadmaps and encourages, amongst others, the implementation of carbon capture and storage (CCS) technologies. Brazil also makes significant investments in advanced R&D programs to explore cutting-edge technologies, such as direct air capture (DAC) and bioenergy with carbon capture and storage (BECCS). The government is also fostering public-private partnerships to accelerate the deployment of these technologies, ensuring a comprehensive approach to reducing the carbon footprint of its industrial activities. Furthermore, financial incentives and subsidies are being provided to industries that demonstrate significant progress in reducing emissions, thereby creating a robust ecosystem for sustainable industrial growth.

South Africa is spearheading decarbonization efforts through its National Business Initiative (NBI) Decarbonization Pathways and Just Energy Transition Partnership. The country is focused on renewable energy integration and the development of low-carbon technologies, particularly in the mining and petrochemical sectors. These sectors have been key to South Africa’s industrial strategy, and the country's engagement with international development finance institutions has been pivotal in driving technological advancements in these areas.

Figure 13: *Country examples with leading frameworks for industrial decarbonization*



Brazil

- Brazil's policy frameworks for industrial decarbonization aim to reduce emissions from key sectors such as steel, cement, and petrochemicals.
- These frameworks include an overarching industrial decarbonization policy further supported by sector specific roadmaps. It is also part of multiple international collaborations like Industrial Deep Decarbonization Initiative (IDDI), New industrial decarbonization Hub

Mexico

- Mexico's policy frameworks for industrial decarbonization aim to reduce emissions from key sectors such as energy, transport, and industry
- The country has passed both laws (Energy Transition Law) and policies like Special Program on Climate Change (PECC). It has also launched a project Deep Decarbonization Pathways Project (DDPP) outlining strategy roadmap for energy systems.

South Africa

- South Africa's policy frameworks for industrial decarbonization aim to reduce emissions from key sectors such as mining, petrochemicals, and manufacturing
- South Africa has also part of Just Energy Transition Partnership, which is contributing USD 8.5 billion for decarbonization. Further , it has launched a strategy - National Business Initiative (NBI) decarbonization Pathways – which focuses on decarbonizing key economic sectors like mining and petrochemicals

India

- Policy frameworks for industrial decarbonization focus on reducing emissions from key sectors like steel and cement.
- These frameworks include fiscal, financial, market-based, and regulatory interventions aimed at promoting energy efficiency, fuel switching, and the adoption of low-carbon technologies such as hydrogen and carbon capture. These are Green Hydrogen Mission, National Action Plan For Climate Change, Perform, Achieve And Trade Scheme, RPO etc.

Thailand

- Policy frameworks for industrial decarbonization aim to reduce greenhouse gas emissions across key sectors such as energy, transport, and industry.
- These frameworks include a mix of regulatory measures, financial incentives, and technological innovations to promote energy efficiency, renewable energy adoption, and low-carbon technologies. These include alternative energy development plan, Climate Change Master Plan, Energy Efficiency Plan etc.

4.6. Landscape of additionality

#06 Where would an intervention in innovative clean energy technologies for smart energy / industrial decarbonization have the most transformational impacts and be most additional in the current policy landscape and countries' national strategies?

SE ID The quantification, measurement and prediction of transformational impact poses conceptual and methodological challenges. On the one hand, transformational impacts may be maximized where economic, environmental, and social factors benefit large populations. However, the degree to which individuals, especially those belonging to marginalized groups, benefit from enhanced economic, environmental, and social conditions also matters for the evaluation of transformational impacts.

While there is no set of indicators that conclusively determines where innovative clean energy technologies will be most transformational and be most additional to existing policy landscapes, the **convergence of benefits across three dimensions**, i.e. economic, environmental, and social benefits, both at the level of individuals and populations plays a fundamental role. Critical insights can be obtained by looking at the following seven factors across the three dimensions:

Figure 14: *Dimensions relevant for transformational impact*

Social

High pollution and health burdens: Clean energy can help to improve air and water quality, leading to better health outcomes for the population. This is particularly important in developing countries where pollution-related health issues are prevalent.

High rural population rate: Limited access to energy impacts rural communities in their livelihoods. Clean energy technologies can provide reliable and affordable energy to these areas, improving living standards, for example through access to education, public services (e.g. healthcare) and economic opportunities.

Environmental

Commitment to decarbonization goals: Net-zero plans and Nationally Determined Contributions (NDCs) signal a commitment to reduce emissions, while strong policy frameworks enable technologies to flourish. This commitment can drive innovation and adoption of clean energy technologies.

Strong presence of heavy industry sectors: The effects of clean energy technologies can be scaled where emission-intensive industries are present. This can lead to significant reductions in greenhouse gas emissions and other pollutants, contributing to global climate goals.

Economic

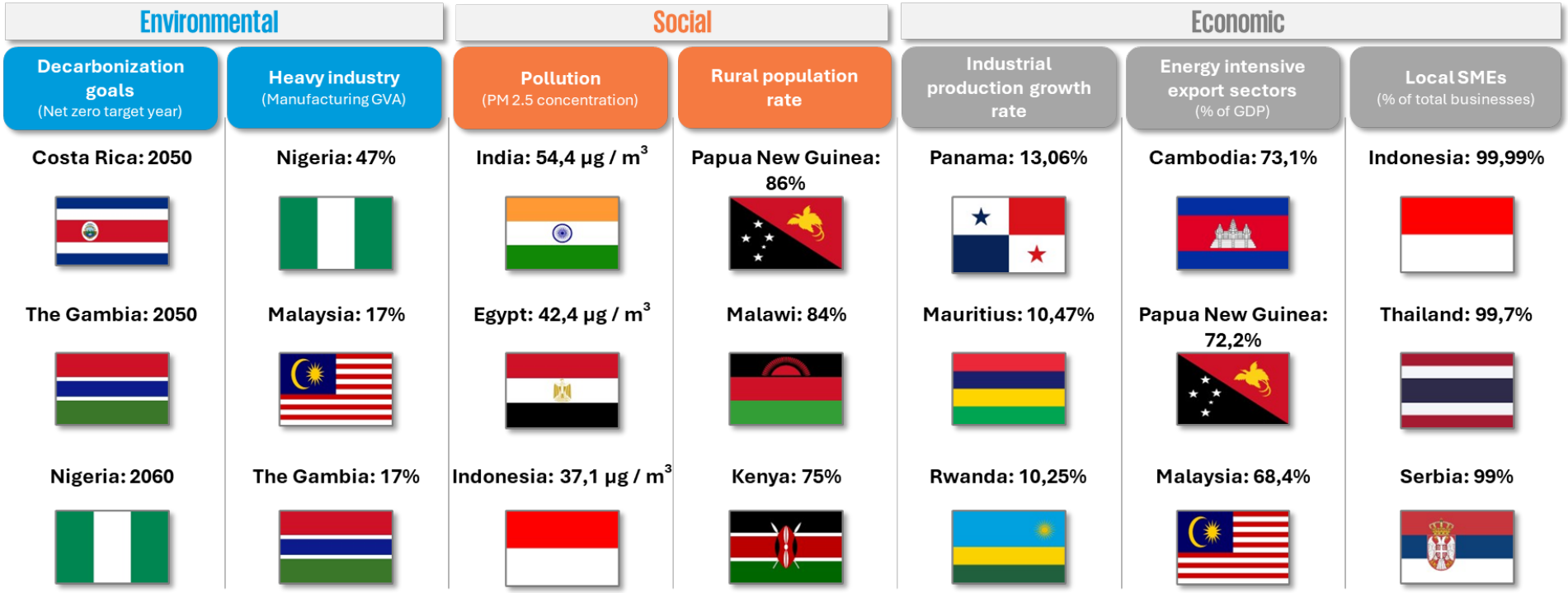
Macroeconomic relevance of local SMEs: Access to reliable, affordable clean energy enables local SMEs to stay in, and possibly expand, business. This can lead to job creation, increased income levels, and overall economic growth, which are crucial for developing countries.

Rapid industrial growth: Industrialization is correlated with increasing emission levels, which can be mitigated through clean energy technologies. This not only helps in reducing the carbon footprint but also ensures sustainable industrial growth.

Presence of energy-intensive export sectors: Developing countries with energy-intensive export sectors can gain a competitive advantage by meeting stricter regulations (e.g., CBAM) and through positioning as leaders in low-carbon manufacturing. This can open up new markets and attract foreign investments.

Transformational impacts are understood as significant changes that alter the fundamental aspects of energy production and consumption, leading to long-lasting improvements across economic, social, and environmental dimensions. With regards to **additionality in existing policy landscapes and national strategies** of different countries the assumption is adopted that interventions in clean energy technologies are most impactful where declared ambitious targets and strong policy frameworks are in place. They are critical conditions for innovative technologies to flourish and for the exploitation of their potential.

Figure 15: *Assessing the deep dive countries across the environmental, social and economic dimensions indicates where transformational impacts from clean energy technology may be strongest*



The results of an analysis of the 28 deep dive countries provides insights into the continent-specific conditions shaping the potential transformational impact in Africa, Asia, and the Americas. (Europe and Oceania not included given the very limited number of countries in scope.)

Africa: High rural population rates and advanced policy frameworks give countries such as Rwanda, Gambia, Kenya and South Africa high potential for transformational impact. Many countries across Africa display high rural population rates, while also having fairly well-developed policy environments for advancing clean energy technologies in place. Some critical bottlenecks, such as access to electricity, while impeding progress, create further potential for transformational impact.

Figure 16: Potential for transformational impact in Africa

Policy and regulatory environment

The policy environment across Africa is largely constituted of **national energy policies and climate action plans** with three key focus areas : 1) renewable electricity, 2) cleaner fuels and 3) energy efficiency

SE **Selected SE policies and plans:**
- **Rwanda**: National AI policy
- **The Gambia**: Digital economy master plan
- **South Africa**: Smart grids vision 2030 document

ID **Selected ID policies and plans:**
- **Rwanda**: Biomass energy strategy vision 2030 document
- **Kenya:** Bioenergy strategy policy
- **South Africa:** CCS Roadmap, Hydrogen society roadmap

Critical bottlenecks

Infrastructure challenges

SE **Low access to electricity** (lack of grids), **technical and commercial losses** (unstable and outdated grids, poor transmission and distribution, **lack of reliable renewables-based power systems**

ID Inadequate **waste management** infrastructure and low recycling levels

Policy and regulatory challenges:

SE Lack of focused policies on smart energy solutions such grids / smart meters, BESS, etc. across Africa;

ID Adoption of circular economy policies and plans still in the early stages

Interventions

SE **Digital, smart and AI energy technologies such as smart grids** will help Africa address the electricity challenges. They improve the reliability of the system, reduce losses and enable integration of renewable energy. **Micro and mini grids** are beneficial especially in off-grid areas.

SE **Battery energy storage solutions** ensure an uninterrupted power supply especially in countries suffering frequent power outages.

ID **Circular economy and material efficiency practices and technologies** need to be adopted. For example: recycling technologies will help minimize waste, maximize resource efficiency and contribute to lower emissions in Africa.

Case studies

SE **Smart energy solutions for Africa (SESA):** Provides energy access technologies across 9 African countries such as smart micro grids

SE **UK-South Africa smart energy global innovation network:** Supports the development and adoption of digital, smart and AI energy technologies such as smart grids

ID **Project development programme (PDP) (Africa):** Develops financially viable projects focusing on, battery storage and energy efficiency

ID **Centre for Excellence for the Circular Economy (Ghana):** Supports organizations and individuals to develop and deploy innovative circular economy technologies and business models

Asia: the region has the most populous countries, depends in many places on hard-to-abate industries and has a heterogenous landscape of relevant policies and initiatives. The size of the populations and the economic development of countries such as India or Indonesia make them critical for realizing global decarbonization efforts and render them key areas for materializing transformational impacts. The relevance of hard-to-abate sectors (e.g., cement and steel) adds to the transformational potential.

Figure 17: Potential for transformational impacts in Asia and Oceania

Policy and regulatory environment

Presence of national energy plans and programs with a focus on key thematic areas such as biomass, renewable energy , energy efficiency and circular economy.

SE **Selected SE policies and plans:**
- **Cambodia:** Energy Tech Roadmap; Science, Technology & Innovation Policy
- **Malaysia:** Energy Transition Roadmap

ID **Selected ID policies and plans:**
- **India:** National policy on biofuels
- **Cambodia:** Circular economy strategy and action plan
- **Malaysia:** National biomass action plan, hydrogen economy and technology roadmap

Critical bottlenecks

Fossil fuel dependence: Reliance on coal and other fossil fuels in heavy industries such as steel and cement

Infrastructure challenges: Inadequate infrastructure (missing or outdated) to integrate variable renewable energy into the existing grid

Policy environment: some countries have extensive policy frameworks in place, yet others (e.g., Indonesia) have only few policies implemented

SE Renewable power development, particularly in the ASEAN region, suffers from inadequate policies

ID National energy frameworks exist but lack concrete plans and roadmap

Interventions

SE **Digital, AI and smart energy solutions such as smart grids:** enable the integration of renewable energy and support modern power systems and clean energy transition.

SE **Micro grids:** create independence from national grids.

ID **CCUS:** can play a critical role in Asian countries in hard-to-abate sectors like steel and cement production which are difficult to decarbonize due to the nature of their processes.

ID **Low carbon cement:** It will lead to the reduction of carbon emissions by using electric energy instead of traditional fossil fuels in production.

Case studies

SE **Wave Powered Micro grid pilot project (Thailand):** design a pilot microgrid project for a remote island in Thailand.

ID **Tangguh CCUS R&D Initiative (Indonesia):** the aim is to reinject over 30 miio t of CO2 initially. This collaboration includes feasibility studies, scholarships and infrastructure support, positioning Tangguh as a potential region of CCS hub and a model for future projects.

ID **SaltX and Dalmia Cement pilot project (India):** This is a pilot project to produce electric cement using Salt X's patented technology Electric Arc Calciner (EAC).

Americas: With UMICs being predominant, the region is economically well developed; existing policies, however, focus primarily on already established technologies. While expanded integration of renewables, enhanced waste management, sustainable transportation solutions, clean energy solutions and biofuel production are integral to the national strategies and policies across the countries in the America, the inclusion of the advancement of innovative technologies currently lags.

Figure 18: Potential for transformational impacts in the Americas

Policy and regulatory environment

Various national energy plans, strategies and policies addressing the integration of renewables, promotion of biofuels and circular economy. However, there are gaps in the policy frameworks related specifically to the advancement of innovative technologies in SE and ID.

SE **Selected SE policies and plans:**

- **Brazil:** Smart Grid Regulation
- **Ecuador:** National Energy Efficiency Plan

ID **Selected ID policies and plans:**

- **Brazil:** RenovaBio (Brazil's biofuel policy)
- **Costa Rica (leading regional practice):** National Decarbonization Plan (2018-2050) - key areas include waste management, energy efficiency, low emission industries and efficient buildings.

Critical bottlenecks

Policy challenges: Lack of comprehensive policy frameworks advancing energy transition, circular economy, waste managements (high dependence on landfills for waste disposal), etc.

Enabling environment deficiencies: Lack of technical capacity and focus on new technologies; dependence on markets with standards and regulations favoring competitiveness over sustainability (e.g., USA).

Infrastructure challenges:

- Limitations to expand integration of renewables due to outdated electricity grids and limited capacity of transmission lines

Interventions

SE **Smart and micro grids:** Modernization of electricity grids using real time data and automation

SE **Battery and energy storage systems:** BESS enable microgrids that operate independently from the main grid, reducing reliance on long distance transmission lines prone to saturation.

ID **Material efficiency and circular economy:** It minimizes waste and maximize resource use by reintegrating waste material back into production cycles

Case studies

SE **RELAC Initiative (Renewables in Latin America and the Caribbean):** Development of country-specific energy storage action plans, driving investment and policy action that accelerates deployment of energy storage across the region.

ID **Supporting the transition to a circular economy in Costa Rica:** Development and creation of a detailed work plan and communication strategy, mapping existing actors and initiatives in circular economy and dissemination of knowledge to key stakeholders.

Key Takeaways – Markets

The **market constraints** affecting SE and ID in developing countries are complex and multifaceted. They consist of political and legal uncertainties, financial limitations, social and cultural barriers, and technological infrastructure challenges all contribute to the difficulties faced in implementing innovative technologies.

While most countries do not have **policies** in place which specifically address technology innovation in SE and ID, there are, however, already ambitious and well-designed policies which address energy transition and industrial decarbonization in place. India, Brazil, Thailand, South Africa, and Mexico in particular have already established policy frameworks and regulatory environments that foster technological innovation in both covered thematic areas.

The potential for **transformational impact** is greatest when economic, social, and environmental factors converge. African countries such as Rwanda, Gambia, Kenya, and South Africa have a high potential for transformational due to high rural population rates, and relatively mature policy frameworks. In Asia, the presence of countries with large populations like India or Indonesia, and dependence on heavy and hard-to-abate industries, present significant opportunities for impactful interventions. In the Americas, many countries are economically more developed but require additional efforts to bridge the gap between existing policy frameworks focused on strategic goals and policies providing incentives for the development and adoption of innovative technology solutions.

4.7. Landscape of initiatives

#07 What are the key existing and planned initiatives, partnerships and collaborations that include an innovation focus in smart energy / industrial decarbonization in developing country contexts, what are the activities-of-focus, in which countries and how are they funded?

SE ID In recent years, the global push towards clean energy technologies and industrial decarbonization has gained momentum, particularly within developing regions. This is also reflected in the various national and international dedicated initiatives related to SE and ID. Initiatives are understood as covering a broader range of activities (e.g., policy development or capacity-building) than projects. They tend to serve as "umbrellas" for a wide range of actors and activities aiming at a specific goal or promoting a specific purpose.

***Figure 19:** National initiatives and technology focus by region*

Examples for national initiatives - Americas

Technology focus

Smart Energy	Industrial Decarbonization
Smart grids	Sustainable fuels
Energy storage systems	Circular economy
Integrating renewable energy (RE) sources	

Examples for national initiatives – Africa and Europe

Technology focus

Smart Energy	Industrial Decarbonization
Smart grids	Sustainable fuels
Energy storage systems	Circular economy
Energy efficiency	Energy efficiency

Examples for national initiatives – Asia and Oceania

Technology focus

Smart Energy	Industrial Decarbonization
Smart grids	CCUS
Big data	Sustainable fuels
Energy storage systems	Circular economy
Energy efficiency	Energy efficiency

There is a dynamic landscape of initiatives driving innovation in both SE and ID. These initiatives are supported by a diverse range of funding sources, including public, private, and community-driven mechanisms. Mapping these initiatives provides a strategic framework for stakeholders to effectively channel their support and involvement, ultimately contributing to the broader goals of global climate and energy strategies.

SE In the context of SE several key regional initiatives exist. In Africa, projects such as "Smart Energy Solutions for Africa" are active in countries including Ghana, Kenya, Malawi, Morocco, Nigeria, Rwanda, South Africa, and Tanzania. Other notable initiatives include the "Project Development Program" and "Energizing Development," which focus on Kenya, Nigeria, Ghana, Rwanda, Malawi, Senegal, and Tanzania. These projects are funded through a combination of public and private sources, supported by international development agencies and partnerships.

In Asia and Oceania, the emphasis is placed on energy efficiency, smart grids, and battery energy storage systems (BESS). Regional efforts in these areas aim to enhance technological infrastructure and operational efficiency.

A prominent case market assessments from the Americas is the "REnovables in Latin America and the Caribbean" (RELAC) initiative. Involving 16 member countries, RELAC is driven by key stakeholders such as the National Renewable Energy Laboratory (NREL), the Global Climate Action Partnership (GCAP), and the Inter-American Development Bank (IDB). The initiative focuses on developing country-specific energy storage action plans, providing capacity building, strategic planning support, and technical assistance. It also aims to create a stakeholder network for knowledge exchange and regional dissemination of content. Funding for RELAC is provided by IDB and NREL, highlighting the role of international collaboration in advancing energy storage solutions.

ID Turning to industrial decarbonization, the market assessment provides an overview of global initiatives focused on various aspects of decarbonization. In Africa, initiatives like the "Project Development Program" and the "Africa Circular Economy Alliance (ACEA)" play a crucial role. ACEA operates across 13 African countries, focusing on material efficiency and circular economy practices. The alliance supports policy development, advocacy, and the scaling of circular economy projects, with funding from a multi-donor trust fund. ACEA's activities include policy development, stakeholder engagement, and support for innovative micro, small, and medium-sized enterprises (MSMEs).

Common focus areas of different initiatives across all regions include CCS / CCUS, material efficiency, circular economy, feedstock and fuel changes, and electrification.

4.8. Landscape of projects

#08 What are the existing and planned programs, projects and work streams that include a focus on innovation in smart energy / industrial decarbonization in developing country contexts, what are the activities-of-focus, in which countries and how are they funded?

SE ID A comprehensive projects database was created to collect and map **ongoing and forthcoming projects** aimed at advancing SE and ID in developing countries. This database consolidates information on relevant projects includes a detailed inventory of projects, encompassing around **100 parameters** categorized into **five main areas**: stakeholders, technology, market constraints, financing, and alignment with Sustainable Development Goals (SDGs).

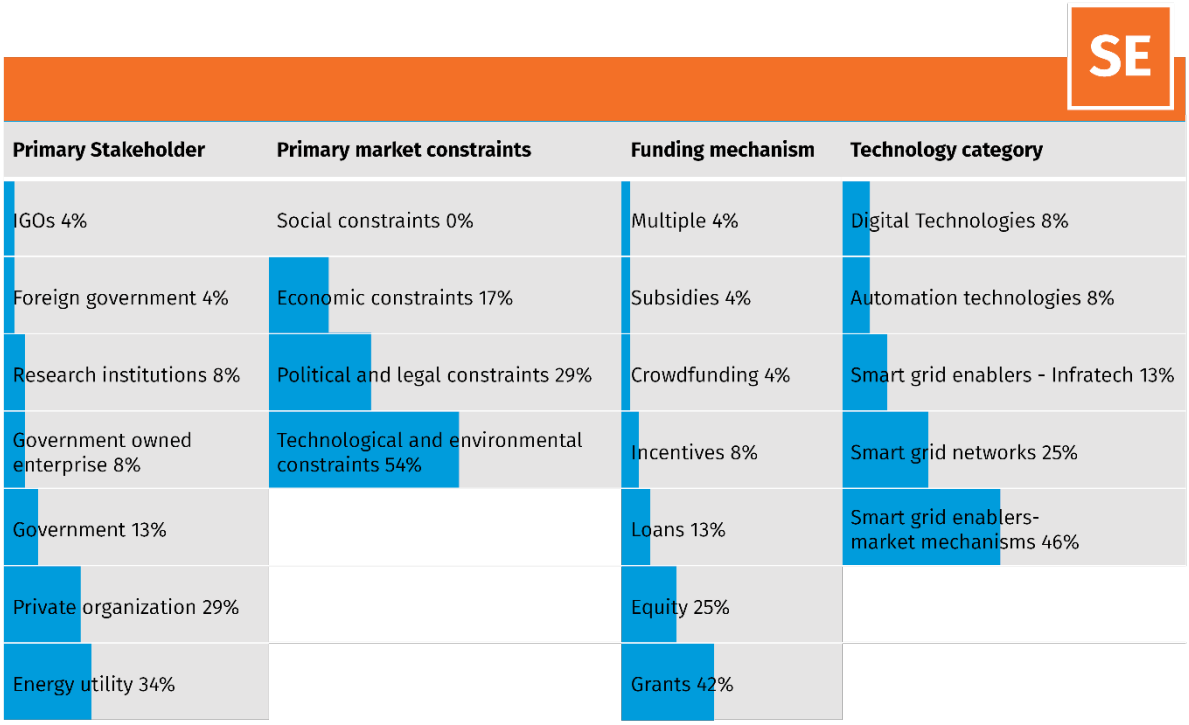
Each project was analyzed based on its primary activities—such as research and development, capacity building, technology deployment, and policy advocacy. Additionally, the projects were mapped against geographic location and funding mechanisms. Sources for this database include renowned existing project databases,

publications from international and multilateral institutions, data from development agencies and accelerators, and information from national and regional organizations.

The projects database provides the basis for creating a curated a portfolio of "lighthouse" projects—pioneering projects that show significant promise for scaling and influencing similar contexts globally. This approach is guided by rigorous criteria assessing innovation impact, scalability, and alignment with SDGs. By focusing on these lighthouse projects, the market assessments aspire to catalyze substantial advancements in smart energy solutions and industrial decarbonization technologies, contributing to a more sustainable and resilient energy future in developing regions.

SE In the context of SE 24 relevant projects across the 28 focus countries were identified. These projects demonstrate significant overlaps in key characteristics, such as stakeholder involvement, market constraints, and funding mechanisms

***Figure** 20: Distribution of key parameters of identified SE projects*



The analysis of SE projects shows:

- Utilities emerge as key players in SE projects as they are the key adopters and implementers of technologies such as smart grids, and virtual power plants.
- The highly innovative nature of the technologies involved has led to most of the project facing technological constrains along with political and legal constrains, often prompted by privacy and security concerns related these technologies.
- The majority of the projects are supported by government grants as governments seek to promote lighthouse projects within smart energy which would drive further interest and investments from other stakeholders.
- Smart grid technologies, especially market enabling mechanisms such as VPP are seeing most activity due to their cost effectiveness and enabling characteristics for renewable and distributed technologies. Further, there is intense activity towards
- Upgrading to smart grid, catalyzed by an increasing need for flexibility and integration of renewables into the grid.

Figure 21: Distribution of key parameters of identified ID projects

ID

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%

ID 32 relevant projects in ID were identified across the 28 focus countries. A notable example in the context of ID is the Indian Oil Corporation Koyali Refinery Project in India, which focuses on capturing carbon dioxide from hydrogen generation units and is set to commence in 2025. This project, funded by the United States Trade and Development Agency (USTDA) and facing regulatory and financial challenges, illustrates the complexities of implementing CCUS technologies.

The analysis of SE 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 majorly due to highly disruptive and cost intensive nature of these technologies especially for technologies like CCUS.
- This has led to most of these projects being supported by government or multilateral grants bridging the gap between the costs associated with these technologies.
- Among the technology types, major adoption is being seen across two levers – industry agnostic technologies like CCUS and alternative fuels, and the other being industry specific technologies which focus on either switching to cleaner fuels or alternate processes.

4.9. Project pipeline

#09 What is the potential portfolio of lighthouse pilot projects for technology innovation in smart energy / industrial decarbonization in developing country contexts?

SE ID In the pursuit of advancing technology innovation in SE and ID within developing countries in a results-driven and effective manner, identifying and leveraging **lighthouse pilot projects** can play a pivotal role. These lighthouse projects represent pioneering efforts in technology implementation and can serve as beacons for scalable and sustainable transformations within their respective sectors. The identification of lighthouse pilot projects is central to understanding how innovative solutions can be effectively deployed in different contexts. Such projects are not only testbeds for new technologies but also crucial in demonstrating practical, scalable solutions that can influence wider industry practices and policy frameworks.

The identification of relevant pilot projects was guided by 18 parameters (see next page for details), including scalability, impact, value-for-money, and additionality. These parameters not only highlight the technical and economic viability of the projects but also their ability to leverage private and wider finance, contribute to knowledge creation, and align with sustainable development goals (SDGs).

The selected projects address critical challenges in both SE and ID, showcasing innovative solutions with significant potential for replication and impact. The 18 parameters for lighthouse project identification and a summary of the respective project pipelines for SE and ID are summarized on the next page.

Figure 22: Criteria and sub-parameters applied for identification of lighthouse projects for the pipeline

The assessment for the identification of lighthouse projects for the project pipeline was based on the following 18 criteria and sub-parameters. Each project was rated as high, medium, or low for each criterion, depending on how well it met the defined sub-parameters. These ratings were then converted into numerical scores. Based on the composite scores, the top 20 projects were designated as lighthouse projects.

Figure 23: Project pipeline: Overview of SE projects

Brazil

Cluster	Americas UMIC
Name of the project	Demand-Driven Electricity Networks Initiative (3DEN)- Planet Smart City
Objective	The projects aims to demonstrate V2G technology for efficient energy use and grid stability. Enabling 500 electric vehicles to feed energy back to the grid.

Panama

Cluster	Americas UMIC
Name of the project	Rural Panama micro/smart power grid sustainability initiative proposal
Objective	The project aims to facilitate blockchain solutions for solar energy transactions and management. Enabling 1,000 solar energy transactions per day.

India

Cluster	Asia LMIC
Name of the project	Digital Twin for Enhanced Electric Distribution Grid Operation and Management (3DEN)
Objective	The project aims to test VPP and V2G technologies for better energy management. Integrating 50 MW of distributed energy resources.

Cluster	Asia LMIC
Name of the project	Tata Power DDL AI enabled smart energy management system
Objective	The project aims to implement smart metering for better energy management and billing. Installing 200,000 IOT enabled smart meters.

Cluster	Asia LMIC
Name of the project	Tata Power DDL VPP pilot
Objective	The project aims to develop a VPP for better energy distribution and management. Integrating 200 MW of distributed energy resources.

Cluster	Asia LMIC
Name of the project	Tata Power India Smart Grid Forum (ISGF) Vehicle-to-Grid (V2G) technology demonstration project
Objective	The project aims to integrate 5G technology for smart grid applications and improved energy management. Covering 100,000 households with 5G-enabled smart meters.

Cluster	Asia LMIC
Name of the project	Pilot on AI and ML for electricity load management - Energy Department of Karnataka
Objective	The project aims to develop smart grid solutions for improved energy distribution and management. Reducing energy losses by 10%.

Thailand

Cluster	Asia UMIC
Name of the project	ERC P2P Electricity Trading - EGAT
Objective	The procet´s objective is to develop a VPP for better energy distribution and management. Integrating 100 MW of distributed energy resources.

Cluster	Asia UMIC
Name of the project	V2G project Nissan Leaf Thailand
Objective	The procet´s objective is to create a digital twin of the city for better energy management and urban planning. Covering 10 km^2 of urban area with digital twin technology.

Cluster	Asia UMIC
Name of the project	ERC Phase 2 VPP and V2G testing - Mitsubishi Motors Thailand
Objective	The project aims to implement AGC for better grid stability and efficiency. Reducing frequency deviations by 30%.

Cluster	Asia UMIC
Name of the project	Mae Hong Son Smart Grid Pilot Project - EGAT
Objective	The project focuses on integrating renewable energy and enhancing grid stability.

South Africa

Cluster	Africa UMIC
Name of the project	MTN and Ericsson's 5G Smart Grid Pilot
Objective	The project aims to integrate 5G technology into smart grid systems, which is measurable through the pilot's performance outcomes.

Cluster	Africa UMIC
Name of the project	Sun Exchange's Solar Energy Blockchain Platform
Objective	The project aims to increase access to clean energy through innovative financing models.

Cluster	Africa UMIC
Name of the project	City of Cape Town's Smart Metering Initiative
Objective	The procet´s objective is improve resource management and efficiency through advanced metering technology.

Cluster	Africa UMIC
Name of the project	Evolve Virtual Power Plant
Objective	The procet´s objective is to maximize the utility of renewable resources and stabilize the national grid, crucial for South Africa's energy diversification goals.

Tanzania

Cluster	Africa LMIC
Name of the project	iGrid Project - Tanzania
Objective	The project aims to implement smart grid technologies for better energy management and efficiency. Covering 50,000 households with IOT enabled smart meters.

Mauritius

Cluster	Africa UMIC
Name of the project	Mauritius - Gas Insulated Switchgear Project
Objective	The procet´s objective is to develop a smart grid for better energy management and distribution. Covering 10,000 households with smart grid technology.

Egypt

Cluster	Africa LMIC
Name of the project	Hitachi-Egyptian Electricity Transmission Company (EETC) Grid Stabilization Project
Objective	The procet´s objective is to assess the feasibility of an AI-driven VPP for better energy management. Integrating 50 MW of distributed energy resources.

Morocco

Cluster	Africa LMIC
Name of the project	RADEEMA smart grid project
Objective	The project focuses to modernize and enhance the energy infrastructure

Serbia

Cluster	Europe UMIC
Name of the project	AI driven Virtual Power Plant Feasibility
Objective	The project focuses on testing and demonstrating the capabilities of AI in managing a virtual power plant.

Figure 24: Project pipeline: Overview of ID projects

Brazil

Cluster	Americas UMIC
Country	Brazil
Name of the project	Aço Verde do Brasil- Carbon neutral steel production
Objective	The project aims to achiee 100% proudction of carbon neutral steel.

Cluster	Americas UMIC
Country	Brazil
Name of the project	FS Lucas do Rio Verde ethanol biorefinery complex - BECCS
Objective	The project focuses on Capturing CO2 from ethanol fermentation; storing CO2 underground

India

Cluster	Asia LMIC
Name of the project	Hydrogen based DRI project by IMMT
Objective	The project aims to produce 500,000 tons of DRI based steel using hydrogen annually

Cluster	Asia LMIC
Name of the project	Pilot Projects on use of Green Hydrogen in the Transport Sector - MNRE, Government of India
Objective	Project commits to sustainable transport solutions and the reduction of greenhouse gas emissions.

Thailand

Cluster	Asia UMIC
Name of the project	Arthit offshore gas field CCS
Objective	The project aims to capture and store 1 million tons of CO2 annually

Cluster	Asia UMIC
Name of the project	Northern Gulf of Thailand CCS Exploration project
Objective	The project aims to establish the feasibility of CCS in Thailand, directly supporting national carbon neutrality goals.

Cluster	Asia UMIC
Name of the project	Meranti Green Steel Plant
Objective	The project aims to produce 500,000 tons of green steel annually.

Indonesia

Cluster	Asia UMIC
Name of the project	Pertamina biorefinery project
Objective	The project aims to produce 200,000 barrels of biofuels annually

Malaysia

Cluster	Asia UMIC
Name of the project	Johor Biorefinery Project
Objective	The project aims to produce 150,000 barrels of biofuels annually

Cluster	Asia UMIC
Name of the project	POSCO Korea-Malaysia CCUS Feasibility Study
Objective	The study aims to assess feasibility of capturing and storing 1 million tons of CO2 annually.

Cluster	Asia UMIC
Name of the project	Hybrid Ocean Thermal Energy Conversion (H-OTEC) Plant
Objective	The project aims to enhance sustainable energy generation.

Cluster	Asia UMIC
Name of the project	Japan-Malaysia Joint CCUS Feasibility Study
Objective	he project's objective is to establish a cross-border CCS chain, enhancing collaboration between Japan and Malaysia and contributing to regional carbon neutrality goals.

Cluster	Asia UMIC
Name of the project	Osaka Biomass Based Methanation Project
Objective	The project aims to produce 100,000 cubic meters of methane annually to target significant reductions in carbon emissions.

Papua New Guinea

Cluster	Oceania LMIC
Name of the project	Papua LNG CCS
Objective	The study aims to assess feasibility of capturing and storing 1 million tons of CO2 annually

Mauritius

Cluster	Africa UMIC
Name of the project	Ocean thermal energy conversion (OTEC) project
Objective	The project focuses on establishing a renewable energy source that is consistent and sustainable, enhancing Mauritius's energy independence

Cluster	Africa UMIC
Name of the project	Deep Ocean Water Applications Project (DOWA) December 2013
Objective	The project aims to utilize deep ocean water for renewable energy and cooling applications, promoting sustainability.

South Africa

Cluster	Africa UMIC
Name of the project	Arcelor Mittal Green Steel Pilot
Objective	The project aims to reduce CO2 emissions by 30% in steel production.

Cluster	Africa UMIC
Name of the project	Leandra CCUS Pilot Project
Objective	The study aims to advance CCUS technologies to mitigate climate impact, supporting national and global environmental goals.

Cluster	Africa UMIC
Name of the project	HySHiFT sustainable aviation fuel project - South Africa
Objective	The project aims to produce 100,000 barrels of sustainable aviation fuel annually

Cluster	Africa UMIC
Name of the project	Anglo American's Hydrogen Truck Project
Objective	The project aims to deploy 50 hydrogen-powered trucks to reduce carbon emissions.

Key Takeaways – Projects and initiatives

A comprehensive and varied **landscape of projects and initiatives** that align with national and international sustainability goals exists across the ODA recipient countries. While a focus on smart grids can be observed in the context of SE, CCUS and alternative fuels production are at the heart of ID projects.

Most of the ongoing **projects face economic and technological constrains** due to the highly disruptive and cost intensive nature of these technologies, especially in the case technologies CCUS. This has led to many projects being supported by government or multilateral grants bridging the gaps between the costs associated with these technologies. In the context of SE technologies **regulatory constraints** also had an impact on existing due to privacy and security concerns arising.

In the pursuit of advancing technology innovation in SE and ID within developing countries in a results-driven and effective manner, identifying and leveraging **lighthouse pilot projects can play a pivotal role**. These lighthouse projects represent pioneering efforts in technology implementation and can serve as beacons for scalable and sustainable transformations within their respective sectors.

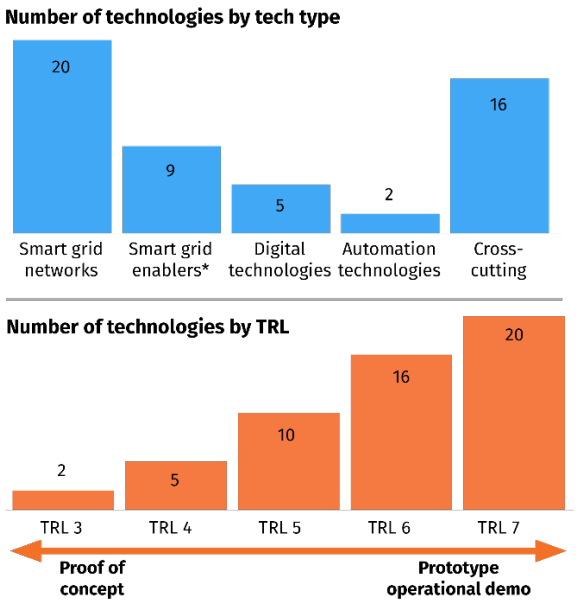
4.10. Landscape of technologies

#10 To what extent are current innovative clean energy technologies in smart energy / industrial decarbonization applied to developing country contexts in the TRLs 3-7 range?

SE Approximately 50 technologies were shortlisted from a broader pool of around 200 technologies identified through key databases, including the IEA Clean Energy Technology Guide and the Entsoe-E Technopedia. The shortlisted technologies, currently at TRLs 3-7, include early prototypes through those undergoing pilot testing. These technologies were analyzed for their relevance to the specific needs and conditions of developing countries.

The assessment of SE technologies focused on their applicability in the developing countries in scope. These technologies are designed to enhance the efficiency, reliability, and sustainability of energy systems and include innovations such as smart grids, advanced grid technologies, and digital solutions that optimize energy management and integrate renewable sources.

***Figure 25:** SE technology types and distribution among TRLs*



Most of the shortlisted smart energy technologies are currently in the post-conception phase, with nearly 50% at prototype or pilot testing stages. These technologies are primarily categorized into several types, including:

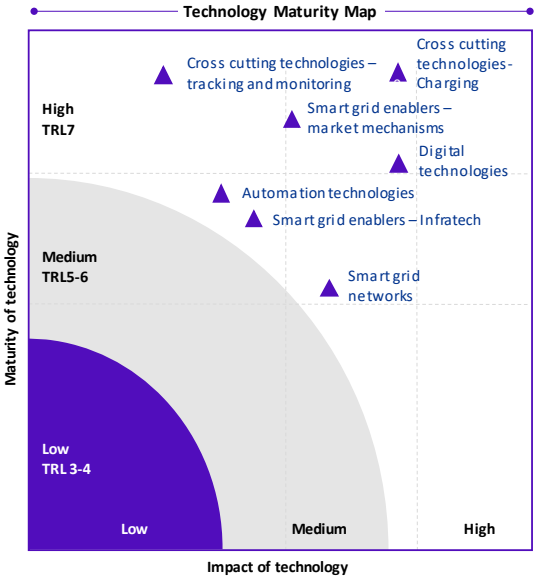
- **Smart grids** allow devices to communicate between suppliers to consumers, allowing them to manage demand, protect the distribution network, save energy and reduce costs. A smart grid provides a two-way flow of electricity, thus helping in adoption of net metering mechanism.
- **Smart grid enablers** – Infratech refers to infrastructure technologies that support smart grid development. These could include hardware, communication protocols, sensors, and monitoring systems.
- **Smart grid enablers - Market mechanisms** in smart grids typically involve pricing models, demand response programs, and energy trading platforms. These mechanisms aim to optimize energy distribution, encourage efficiency, and enhance grid stability.
- **Digital technologies** can help integrate the growing share of renewables into the existing infrastructure by delivering flexible electricity systems that provide demand side solutions and energy storage.
- **Automation and Artificial Intelligence (AI)** can solve challenges related to rising power demand, efficiency, changing supply and demand patterns, and provide analytics needed for optimal management.

Regional analysis indicates varied adoption patterns. In Africa, the focus is on partial grid upgrades and market mechanisms due to limited infrastructure and capital, with key projects such as smart grid networks in South Africa and grid stabilization in Tanzania.

Asia shows higher adoption of innovative technologies due to better infrastructure and supportive policies, with ongoing projects including smart grid networks in India and Indonesia.

The Americas, EU, and Oceania demonstrate significant activity in smart grid networks and market-based mechanisms, with projects in Brazil, Panama, and Oceania focused on smart grids and fast charging infrastructure.

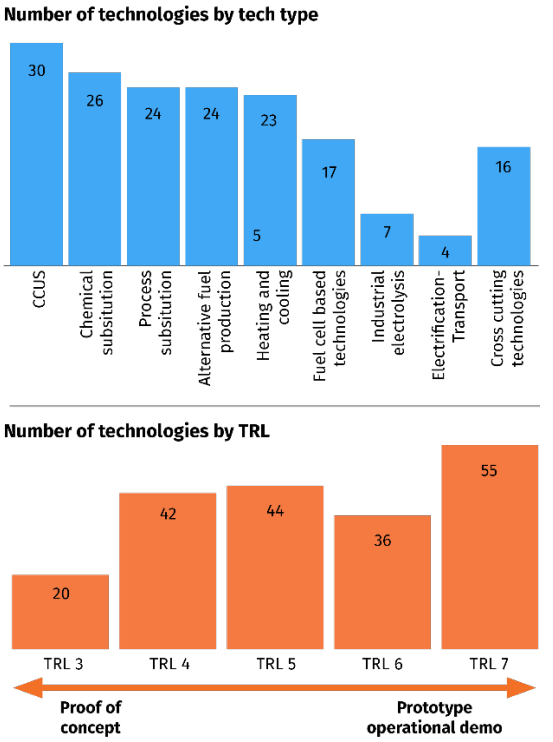
Figure 26: *SE technology maturity map*



Overall, while notable advancements have been made, ongoing efforts are necessary to address barriers such as limited infrastructure and financial resources.

ID The exploration of ID technologies addressed their deployment and impact in developing countries. This field focuses on reducing GHG-emissions from industrial processes through technologies that capture or reduce emissions or transition to more sustainable practices. 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, CCUS being the most researched one globally.

Figure 27: *ID technology types and distribution among TRLs*

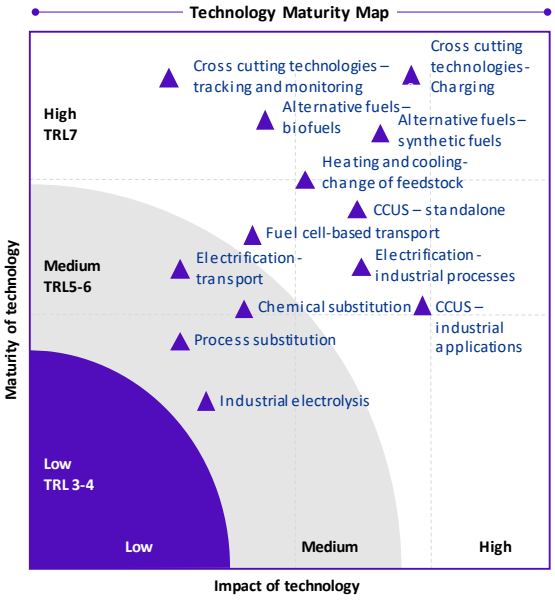


Key technology groups include:

- **CCUS technologies**, such as chemical absorption and solid oxide fuel cells, are explored for their effectiveness in reducing CO_2 emissions.
- **Alternative fuel production technologies**, including biofuels and hydrogen, are gaining attention for their potential to reduce emissions in various industrial processes.
- **Heating and cooling systems** focus on transitioning from fossil fuels to renewable energy sources.
- **Electrification** involves switching from fossil fuels to electricity, particularly in industrial processes.
- **Industrial electrolysis** is used to produce hydrogen or other chemicals through electrochemical processes. Research focuses on efficiency improvements and cost reduction.

- **Fuel cells** generate electricity and heat through an electrochemical reaction, contributing to ultra-clean baseload power and providing a backup solution. This involves the use of mainly vehicles powered by fuel cells (which generate electricity from hydrogen) for transportation.
- **Process substitution** involves replacing energy-intensive or environmentally harmful processes with more sustainable alternatives.
- **Chemical substitution** aims to replace hazardous or polluting chemicals with safer alternatives. This involves replacing high-emission chemicals or materials with lower-emission alternatives.

Figure 28: ID technology maturity map



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, EU, and Oceania 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.

Case studies, such as the Kasawari Carbon Capture and Sequestration (CCS) Project in Malaysia, illustrate the integration of innovative and funding strategies within a single stakeholder, reflecting the traction of mature technologies in developing contexts.

The analysis of mid-stage SE and ID technologies in developing countries highlights their potential to significantly impact local energy and industrial sectors. While substantial progress has been made, challenges such as limited infrastructure, financial constraints, and regulatory barriers must be addressed to facilitate broader adoption.

Key Takeaways – Technology landscape

The technology landscape in SE and ID develops dynamically with **more than 500 technologies** identified by the IEA across the whole TRL spectrum.

In the context of SE, innovation is focused on enhancing the robustness, efficiency, and flexibility of the electricity grid to integrate variable renewable energy sources seamlessly. Around **50 relevant smart energy technologies** within TRL 3 to 7 can be identified, most of which are in the prototype or pilot testing stages. Key technologies include smart grids, demand response systems, and virtual power plants, which are supported by digital technologies such as AI, Machine Learning, Blockchain, and IoT. These advancements make energy infrastructure smarter and more connected, significantly improving productivity and energy efficiency. There is substantial uptake of these technologies in highly populous middle-income countries, such as India and Indonesia, which are transitioning towards more advanced and connected electricity grids.

In the context of ID, innovation is centered on replacing emission-intensive technologies with low-carbon alternatives. This includes the development and prototyping of various CCUS technologies and the use of alternative fuels and hydrogen in industrial processes. **Approximately 200 industrial decarbonization technologies exist, with nearly 50% of them being at the prototype or pilot testing stages.** These technologies are essential for emission reduction and energy efficiency improvement in hard-to-abate sectors such as metals, mining, chemicals, and petrochemicals.

Cross-cutting technologies that improve overall process and energy efficiency, such as advanced charging and monitoring technologies, are also crucial for achieving broader sustainability goals.

4.11. SDG assessments

#11 What are the evidence-based theories of change for supporting technology innovation in smart energy / industrial decarbonization in developing country contexts against the most relevant SDGs?

SE ID Theories of change illustrate how desired impacts can be achieved through relevant inputs, activities, outputs, and outcomes. The core SDGs of the A2D Facility are **SDG 1** (No Poverty), **SGD 9** (Industry, Innovation, and Infrastructure), and), **SDG 13** (Climate Action). While countries are assessed by the UN with regards to the promotion of the SDGs (see Appendix), innovative technologies can also be assessed with regards to their ability to promote the SDGs.

For instance, biorefining and biomass gasification technologies, including ammonia production, directly contribute to SDGs 1, 9, and 13. These technologies improve energy access and reduce emissions while fostering industrial innovation. Carbon Capture, Utilization, and Storage (CCUS), solid oxide fuel cells, and technologies such as ultra-fast charging and automated connected vehicles align with SDGs 9 and 13 by enhancing industrial sustainability and reducing greenhouse gas emissions. Additionally, these technologies also support other SDGs such as 7 (Affordable and Clean Energy), 12 (Responsible Consumption and Production), 3 (Good Health and Well-Being), and 11 (Sustainable Cities and Communities) through their ancillary benefits.

***Figure 29**: Impact of key SE technologies on central SDGs, underlying rationale, and co-benefitting SDGs*

Key Technologies	1 NO POVERTY	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	13 CLIMATE ACTION	Co-Benefit SDGs	Rationale for Co-Benefit SDGs
Digital twin				4, 8	Promotes quality education through advanced learning tools and improves industry processes
Virtual power plants				7, 11	Fosters affordable clean energy access and helps cities manage energy more sustainably and efficiently
Supercapacitor in hybrid storage				7, 11	Enhances clean energy use and enhances the resilience and efficiency of urban energy systems
Cloud and edge computing				4, 8	Supports quality education with better data management and creates new job opportunities
Distributed ledger technology (DLTs) / Blockchain				8, 16	Streamlines business processes and facilitates secure and transparent transactions
Cell-to-chassis battery technology				7, 11	Enhances sustainable energy use and supports industry innovation and the development of greener cities
Rail-to-grid energy storage system				7, 11	Stores and manages renewable energy and supports sustainable cities manage energy more efficiently

One significant case study highlights the impact of **CCUS technologies** on SDG 13. The theory of change for CCUS underscores the role of policy advocacy and development, which involves establishing regulatory frameworks to promote private sector investment and creating carbon pricing mechanisms to incentivize emission reductions.

Public-Private Partnerships (PPPs) play a crucial role by leveraging private sector expertise and resources, facilitating joint ventures, and ensuring effective collaboration. Infrastructure development is also vital, with investments in capture facilities, transportation networks, and storage sites being necessary to support CCUS deployment. The outputs of these initiatives include supportive policies and regulations, effective PPPs, and enhanced infrastructure that collectively advance SDG 13.

The impact substantial: CCUS technologies contribute to significant reductions in greenhouse gas emissions, strengthen the capacity of developing countries to implement climate strategies, and promote sustainable industrial practices. This results in improved environmental sustainability and resilience, along with long-term economic and social benefits.

Figure 30: Impact of key ID technologies on central SDGs, underlying rationale, and co-benefitting SDGs

Key technologies	1 NO POVERTY	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	13 CLIMATE ACTION	Co-Benefit SDGs	Rationale for Co-Benefit SDGs
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

Key Takeaways – SDG and impacts

Promoting Sustainable Development Goals (SDGs) occurs at both country and technology levels. The enabling environment provided by each country affects the promotion of SDGs.

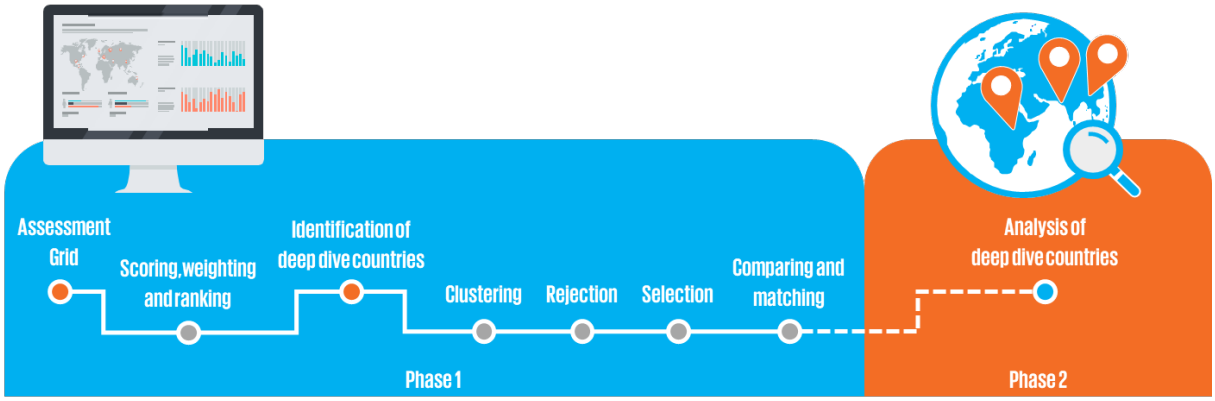
Smart energy technologies enhance energy access and reliability, driving economic growth, improving living standards, and reducing poverty, thereby supporting **SDG 1** (No Poverty).

Industrial decarbonization technologies, such as CCUS, alternative fuel production, and hydrogen utilization, promote **SDG 9** (Industry, Innovation, and Infrastructure) and **SDG 13** (Climate Action) by replacing emission-intensive processes with low-carbon alternatives, improving industrial efficiency, and reducing greenhouse gas emissions. The integration of digital technologies further amplifies these impacts, fostering sustainable development in developing countries.

5. Methodology and data collection

5.1. Methodology

Figure 31: *Methodology overview*



The market assessments were structured along two phases. Phase 1 involved the clustering and selection of representative lead countries from the 141 developing countries. Phase 2 focused on a comprehensive analysis of the selected countries chosen for further analysis.

The rationale for dividing the market assessments into two phases was the aim to first identify the relevant focus countries that would provide particularly relevant insights due to the strength of the enabling environment they provide in the context of technology innovation in developing countries. Phase 2 was dedicated to answering the eleven research questions (see chapter 2 – Delineation of assessment scope).

This was achieved by leveraging a broad network of experts through interviews and surveys, as well as by carrying out comprehensive analysis of quantitative and qualitative secondary data from carefully selected, high-quality sources. The transition from Phase 1 to Phase 2 also marked a shift in focus from a primarily geographic assessment to a technological (project) perspective.

5.1.1. Assessment grids

Assessment grid objective:

The assessment grid was designed to facilitate a systematic evaluation and prioritization of developing countries for investment in smart energy and industrial decarbonization projects. The grid provided a comprehensive analysis of each country's readiness, capacity, and potential impact, ensuring that investments are strategically targeted to maximize both economic, environmental and SDG outcomes, particularly SDG 1 (No Poverty), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action).

Assessment grid structure:

The assessment grid is comprised of seven indicator groups, each of which is weighted to reflect its relevance in determining a country's suitability for smart energy and industrial decarbonization investments. The grid is divided into two categories of indicators: common (enabling environ-ment) indicators and theme-specific indicators for both smart energy and industrial decarbonization respectively.

Key assessment grid components:

- 141 Countries: Coverage of the complete DAC list of 141 ODA recipient countries.
- 73 Indicators: A total of 73 indicators to evaluate various aspects of the countries:
  - 57 common indicators across both SE and ID assessment grids,
  - 8 dedicated indicators for each the SE and the ID assessment grids.
- 7 Indicator Groups: The indicators are categorized into a total of seven groups:

Five common groups for both thematic areas, and one unique group for each thematic area.

Within these two thematic areas both current efforts and progress, and presence of enabling environment, and future readiness through progress on policy and regulatory front were assessed.

While the A2D Facility has all developing countries in scope, the assessment grids provide a structured and data-driven approach to identifying particularly suitable countries for investment in smart energy and industrial decarbonization projects. Moreover, the selection of countries that excel in various performance indicators, including their contribution towards the SDGs, provided the market assessments with a focus that allowed drawing highly valuable insights about key markets, relevant enablers, and constraints in the context of technology innovation in smart energy and industrial decarbonization.

Scoring, weighting, and ranking:

- Enabling environment: Weighted score for each country is calculated based on its performance across the five common enabling environment indicator groups.
- Smart energy: Weighted score for each country across smart energy indicators.
- Industrial decarbonization: Weighted score for each country across industrial decarbonization indicators.
- Ranking of 141 countries: all ODA recipient countries were ranked according to their performance across the indicator groups, generating two lists, i.e., one for smart energy and one for industrial decarbonization.

5.1.2. Identification of deep dive countries

Clustering philosophy and methodology

The objective was to identify an effective approach to grouping countries based on the assessments' criteria, rather than strictly adhering to a fixed number of clusters. Country grouping applied regions and income levels as fundamental parameters.

Regions:

- Rationale: Grouping countries by continent acknowledges the shared geographical, climatic, cultural, and socio-political factors that can influence energy policies and industrial practices. This regional context helps in understanding and addressing common challenges and opportunities within a specific geography.
- Continents considered: Africa, Asia, Europe, Americas, and Oceania.
- Source: KPMG has used the latest edition (year 2024) of UNIDO country classification for this purpose (Link)

Figure 32: Indicator groups, their weightage and brief description

Scope	Indicator group	Weight	Brief description of indicator groups
Common for the two assessment grids across both thematic areas (enabling environment)	**Macroeconomic**	10%	Assessment of the economic stability and potential for investment in new technologies and infrastructure.
	Demographic and social	10%	Insights into scale, quality, and availability of human capital, enabling infrastructure and performance on DEI. These indicators play an important role in decision making related to potential investment.
	Geopolitical stability and governance	10%	Evaluates if the countries have stable environments conducive to the successful implementation of long-term projects and governance that can support transformative energy and climate initiatives.
	Sustainability and climate resilience	10%	Critical for understanding the environmental context and the urgency of decarbonization efforts, as well as the potential impact of climate change on project sustainability.
	Innovation readiness	10%	Promotion of and readiness for innovation is essential for adopting and scaling smart energy solutions.
Smart energy assessment grid only	**Smart energy**	50%	The indicator group exclusively covering indicators related to smart energy has been allocated the highest weight in the smart energy thematic area as it directly assesses a country's capabilities and readiness for smart energy technologies. Indicators include: ▪ EV policy and targets ▪ EV penetration (also a proxy for charging infrastructure) ▪ Energy storage policy and capacity ▪ Smart grid and micro-grid policies ▪ AI and IoT enabling smart energy technologies ▪ Energy efficiency policies ▪ VRE percentage for electricity generation These indicators collectively reflect the country's infrastructure, regulatory environment, and market readiness for smart energy solutions.
Industrial decarbonization assessment grid only	**Industrial decarbonization**	50%	The indicator group exclusively covering indicators related to industrial decarbonization has been given the highest weight in the industrial decarbonization thematic area as it directly evaluates a country's efforts and readiness to reduce industrial emissions. Indicators include: ▪ Annual industrial sector GHG emissions ▪ Industrial emissions intensity ▪ Presence of decarbonization policies ▪ Supply chain decarbonization initiatives (including scope 3 emissions and transportation) ▪ Circular economy policies (circularity, end-of-use, material efficiency, design and procurement) ▪ Energy efficiency policies (a main pillar of decarbonization as per IEA) ▪ Net zero goals (long-term ambition) ▪ Regulatory compliance and incentives for emissions reduction (carbon pricing, ETS, CBAM). These indicators show if the selected countries have the necessary policies, infrastructure, and commitment to industrial decarbonization.

Income classification:

Rationale: Grouping countries by income levels allows for the consideration of economic capacities and developmental stages. Countries at similar income levels often face comparable economic challenges and opportunities, making this an effective way to tailor interventions that are appropriate to their economic context.

Income levels considered were Least Developed Countries (LDC), Low-Income Countries (LIC), Lower to Middle-Income Countries (LMIC), Upper to Middle-Income Countries (UMIC). These groups are based on per capita gross national income (GNI). Source: Development Assistance Committee (DAC) list of ODA recipients by the OECD.

The clustering methodology which is based on dividing countries across continents by DAC income classifications, leverages natural groupings such as Africa LDC and Asia LMIC. This provides fair representation across geographies and economic performance, allowing for a diversity of potential impacts that can be achieved by A2D investment.

Additionally, this nuanced grouping allows for tailored analysis, acknowledging the unique context each cluster presents. This strategy enhances the relevance and impact of insights, guiding targeted interventions in smart energy and industrial decarbonization. The process yielded the following 15 clusters:

Figure 33: Regional income clusters

	Africa (53)	Asia (36)	Europe (9)	Americas (27)	Oceania (16)
LDC (45)	Africa LDC **(33)**	Asia LDC **(8)**	No country	Americas LDC **(1)**	Oceania LDC **(3)**
LIC (2)	No country	Asia LIC **(2)**	No country	No country	No country
LMIC (35)	Africa LMIC **(13)**	Asia LMIC **(13)**	Europe LMIC **(1)**	Americas LMIC **(3)**	Oceania LMIC **(5)**
UMIC (59)	Africa UMIC **(7)**	Asia UMIC **(13)**	Europe UMIC **(8)**	Americas UMIC **(23)**	Oceania UMIC **(8)**

Rejection criteria for country selection

To identify less attractive countries for in-depth analysis and eventual investments, a number of rejection criteria were applied, including very high inflation, instability, junk credit ratings and very low population.

1 – Inflation rate

Criterion: inflation rate > 20% p.a.

High inflation is a critical rejection criterion due to the following factors:

1. Economic instability: High inflation often signals broader economic instability, which can impact investments negatively, leading to riskier environments for initiating and sustaining projects.
2. Cost variability: High and unstable inflation render costs unpredictable, complicating budgeting and financial planning for long-term projects.
3. Monetary policy volatility: High inflation can lead to unexpected policy changes as governments attempt to stabilize the economy.
4. Reduced purchasing power: High inflation erodes purchasing power, which in turn affects consumer behavior, and potentially reduces public and private sector investment in projects.

These factors make high-inflation countries less attractive for in-depth analysis and eventual investment, favoring more stable environments for the successful implementation of innovative technology projects in smart energy and industrial decarbonization.

2 – Credit rating

Criterion: Junk rating (i.e., 'C' as per Moody's nomenclature)

1. Financial instability: Low credit ratings often indicate economic instability, which can jeopardize the successful implementation and sustainability of investment-heavy projects.
2. Risk of default blocking access to finance: Poor credit ratings suggest a higher risk of financial default, which can lead to difficulties in securing funding and maintaining cash flows necessary for project completion.
3. Regulatory and political risk: Economically unstable environments often correlate with political and regulatory instability, which may introduce unpredictable risks to project timelines and outcomes.

Focusing on countries with at least a moderate level of creditworthiness ensures that investments are made in environments where the financial, regulatory, and political landscapes are conducive to success and sustainability.

3 – Political stability and absence of violence and terrorism

Criterion: Stability score < -1.8

Investment risk: High political instability or violence significantly increases the risk to investments, potentially leading to project delays, increased costs, or failure.

1. Operational challenges: Unstable political environments can disrupt project operations, logistics, and the safety of personnel, impacting project feasibility and timelines.
2. Regulatory uncertainty: Political instability often leads to regulatory unpredictability, which can complicate compliance, impact financial returns, and deter future investment.

Selecting countries with better stability scores ensures a more predictable and secure environment for implementing and sustaining energy and decarbonization projects.

4 – Corruption perception index

Criterion: Corruption Perception Index >160

High corruption often leads to:

1. Operational risks: Corruption can introduce inefficiencies and unpredictability in business operations due to uncertain regulatory environments and the potential for arbitrary decision-making.
2. Legal and reputational risks: Engaging in regions with pronounced corruption levels

can expose investors and cooperation partners to legal penalties under international anti-corruption laws and negatively impact their reputation.

3. Financial risks: Corruption increases the cost of doing business and can undermine the economic viability of projects due to potential for fraud, misappropriation of funds, or inflated project costs.

Therefore, selecting countries with better scores on the Corruption Perception Index helps mitigate these risks, ensuring a more stable and predictable environment for investment.

5 – A2D / UNIDO exclusion due to limited impact potential

Criteria:

1. ***Saturated markets:*** countries with well-developed and competitive markets for both smart energy and industrial decarbonization technologies in which global and domestic players are already heavily invested are expected to benefit less from additional investment and yield comparatively lower marginal returns.
2. ***Overserved and highly advanced regions:*** countries with established presence of advanced technologies and relevant funding in place have a comparatively lower need for external support and investment, than countries that cannot leverage innovative technologies due to limited access and funding. This approach ensures a broader geographic impact and promotes technology diffusion in regions that are often underserved.

Exceptions to the criteria above: pilot projects with global rollout potential or lighthouse projects

This ensures that truly innovative and impactful initiatives are not overlooked. These projects can serve as models or "lighthouses" for other countries, demonstrating successful implementation that can be replicated globally.

Although not a strict requirement, one of the objectives is to guarantee that the clustering model mirrors the number of countries across the various regions. For example, among the 141 ODA recipient countries, Africa and Asia constitute 64% of the developing countries (see table below).

Figure 34: *Distribution of ODA recipient countries*

Continent	Number of	% Split
Africa	53	38%
Asia	36	26%
Americas	27	19%
Oceania	16	11%
Europe	9	6%
Total	141	100%

After the application of the rejection criteria, the 141 ODA recipient countries were mapped across the 15 region- and income-level-based clusters (see Table 2 above). Next, 35 highly relevant countries were selected for each of the two thematic areas based on:

- Performance on the respective assessment grids
- Country selection philosophy
- Ensuring sub-regional representation and diversity

Selection of deep dive countries

Following the ranking, the top 30% of countries from each cluster were identified to avoid favoring Upper-Middle-Income Countries (UMICs) over other categories, especially Least Developed Countries (LDCs).

Selection criteria

1. ***Robust enabling environment:*** Prioritize countries with a strong foundational environment that supports smart energy and industrial decarbonization. This includes stable governance, favorable regulatory frameworks, and existing infra-structure that can facilitate the implementation of advanced technologies.
2. **Potential for improvement, trans-formational impact, and scalability:** Focus on countries that, despite having a robust enabling environment, still possess significant untapped potential for improvement. These countries offer opportunities for transformational impact in terms of energy efficiency, renewable energy adoption, and industrial

decarbonization. For example, regions like Latin America, with abundant renewable energy resources such as solar, wind, and hydroelectric power, can be leveraged for sustainable development. Also, prioritize regions where successful interventions can be scaled up or replicated in other contexts to maximize overall impact.

3. **Alignment with SDG goals:** Select countries that align with the Sustainable Development Goals (SDGs). Emphasize regions where interventions can address energy poverty (indirectly related to SDG 1), improve industrial efficiency (SDG 9), and reduce greenhouse gas emissions (SDG 13). These efforts contribute to broader development goals, including economic growth, job creation, and environmental sustainability. Focus on regions that need support to meet their broader development goals by addressing these key areas.

Figure 35: *Countries selected for both thematic areas*

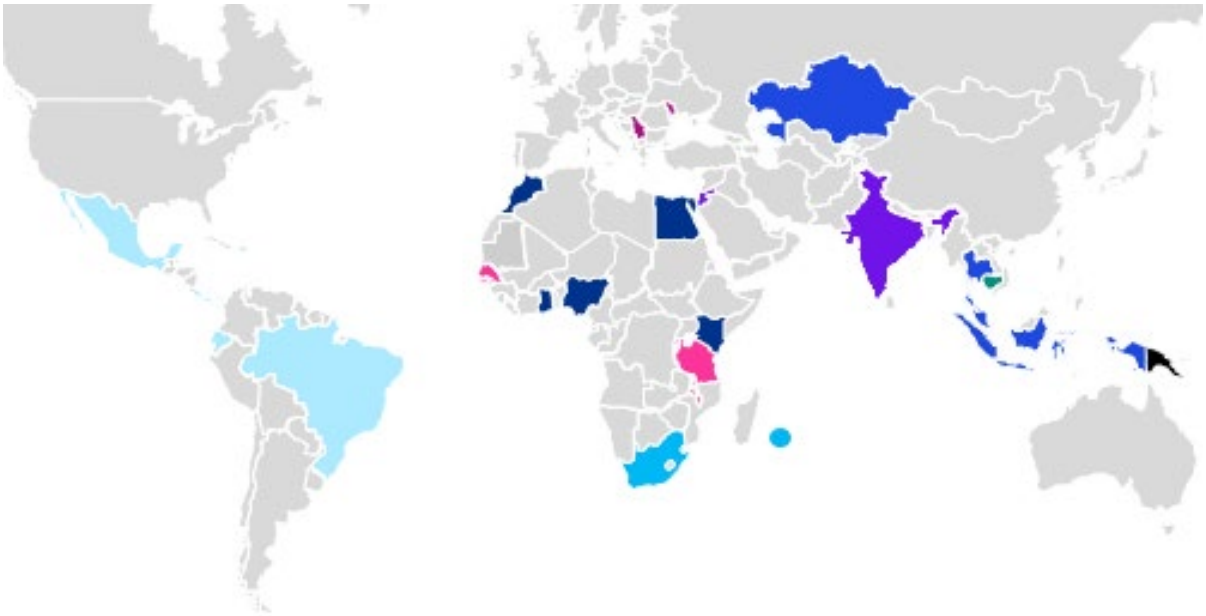
Smart Energy			
Malawi	Philippines	Egypt	Dominican Republic
Uganda	India	Morocco	Costa Rica
Rwanda	Jordan	Ghana	Mexico
Tanzania	Kazakhstan	Nigeria	Panama
Senegal	Indonesia	Mauritius	Papua New Guinea
The Gambia	Malaysia	South Africa	Brazil
Lesotho	Thailand	Cambodia	Ecuador
Kenya	Turkey	Colombia	Peru
Moldova	Serbia	Uzbekistan	Bangladesh

Industrial decarbonization			
Malawi	Vietnam	Egypt	Dominican Republic
Mozambique	India	Morocco	Costa Rica
Rwanda	Jordan	Ghana	Mexico
Tanzania	Kazakhstan	Nigeria	Panama
Senegal	Indonesia	Mauritius	Papua New Guinea
The Gambia	Malaysia	South Africa	Brazil
Togo	Thailand	Cambodia	Ecuador
Kenya	Kyrgyzstan	Colombia	Nepal
Moldova	Serbia	Georgia	

Comparing and matching

This approach resulted in two lists of the top 35 countries across the two thematic assessment grids. From these lists, a final selection of 28 underwent further analysis, as they demonstrated particular strengths in both focus areas and were able to facilitate the examination of the five core areas of analysis and answering the eleven key research questions of the market assessments. (Note: Exceptional countries from the two assessment grids were also considered, even if they did not appear on both lists).

Figure 36: Geographic spread of countries selected for Phase 2 country deep dive



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

5.2. Data collection

5.2.1. Secondary Data

The centerpiece of systematic and comprehensive secondary data collection during phase 1 of the market assessment is a tailored analysis framework – the assessment grid. It contains a broad range of indicators and parameters, providing information on each country (e.g., economic development, political stability, population growth, key industries, energy mix, global innovation index, alignment with SDGs 1, 9 and 13) that are relevant for evaluating the market potential and for answering the eleven research questions as defined per the ToR. The assessment grid is described below in section 3.

Relevant **secondary data sources** include academic journals and publications from various private, public, and intergovernmental actors including the UN, OECD, World Bank, World Economic Forum, International Energy Agency, and different development banks.

The quality assurance for the secondary data collection is based on a comprehensive scoring mechanism for which five key quality indicators are defined. All key indicators have assigned scores, which add up to a total of 12 points.

In the next step, the respective values and totals are calculated. All data sources with a score of less than 8 are discarded. This leads to a total of 32 data sources that have passed the scoring.

Figure 37: Data quality criteria

Key quality indicator	Definition	Max. score
Frequency of updating data	The frequency is divided into three categories: ▪ 1 to 2 years = 2 points ▪ 3 to 4 years = 1 points ▪ 5 years and above = 0 points	**2**
Clarity	A higher score (0-3 points) is given to sources that are easily understandable, enhancing readability and simplifying interpretation for the analysis.	**3**
Reliability	A higher score (0-3 points) is awarded to sources from well-established and reputable organizations, reflecting stronger trustworthiness and accuracy in the data provided.	**3**
Data recency	A higher score is given to sources with more recent data - no country gets a zero since only relatively recent sources were considered. Sources after 2020 (included) are given a score of 2.	**2**
Coverage	A higher score is assigned to sources covering more countries, indicating broad applicability and enhancing the relevance of insights across different geopolitical contexts. If the coverage is over 75% of target countries, a score of 2 is given, else 1.	**2**

Figure 38: Data sources

Organization Name	Database/Index/Report	Frequency of Updating Data	Clarity	Reliability	Data Recency	Coverage	Total Score	%
United Nations	UNDP Data Center	2	3	3	2	2	12	100%
	Gender Inequality Index	2	3	3	2	1	11	92%
	UNESCO Database	2	3	3	2	2	12	100%
	UNIDO Statistics Portal	2	3	3	2	2	12	100%
	UN SDG Indicator Database	2	3	3	2	2	12	100%
World Bank	RISE Database	2	3	3	2	2	12	100%
	Global Solar Atlas Database	2	3	3	2	2	12	100%
	Global Wind Atlas Database	2	3	3	2	2	12	100%
	World Bank Open Data	2	3	3	2	2	12	100%
	Political Stability Index	2	3	3	2	2	12	100%
	World Governance Index	2	3	3	2	2	12	100%
	Ease of Doing Business Rankings	1	3	3	1	2	10	83%
	World Bank Carbon Pricing Dashboard	2	3	3	2	2	12	100%
	WBL Data	2	3	3	2	2	12	100%
International Monetary Fund	World Economic Outlook	2	3	3	2	2	12	100%
IRENA	IRENA Database	2	3	3	2	2	12	100%
Emissions Database for Global Atmospheric Research	Emissions Database for Global Atmospheric Research Database	2	3	3	2	2	12	100%
Moody's Ratings	Moody's Sovereign Credit Ratings	2	3	3	2	2	12	100%
US Energy Information Administration	EIA Database	2	3	3	2	2	12	100%
Transparency International	Corruption Perception Index	2	3	2	2	2	11	92%
University of Notre Dame	Notre Dame Global Adaption Initiative - Country Rankings	2	3	2	2	2	11	92%
US Department of Energy	Sandia Database	2	3	2	2	2	11	92%
Cable.co.uk	Worldwide Data Pricing Dataset	2	3	1	2	2	10	83%
Germanwatch	Global Climate Risk Index	2	3	2	2	1	10	83%
Institute for Global Environment Strategies	IGES NDC Database	2	2	2	2	2	10	83%
Oxfam	Commitment to Reducing Inequality Index	2	3	2	2	1	10	83%
WEF	Global Gender Gap Index	2	3	2	2	1	10	83%
World Resources Institute	Climate Watch Database	2	3	2	2	1	10	83%
Yale Center for Environment Law and Policy	Environmental Performance Index	2	2	2	2	2	10	83%
Climate Policy Database	Climate Policy Database	3	1	2	2	2	10	83%
World Intellectual Property Organization	Global Innovation Index	2	2	2	2	1	9	75%
Council on Foreign Relations	Workplace Equality Index	2	3	1	1	1	8	67%

5.2.2. Bibliography

AEEP (Africa-Eu Energy Partnership) website available at: AEEP | Africa-EU Energy Partnership

Allen, C., Malekpour, S., (2023), Unlocking and accelerating transformations to the SDGs: a review of existing knowledge.

Breakthrough Energy (2019), Advancing the Landscape of Clean Energy Innovation, HIS Markit and Energy Futures Initiative.

Chan Y., Petithuguenin L., Fleiter T., Herbst A., Arens M., Stevenson P. (2019), *Industrial Innovation: Pathways to deep decarbonisation of Industry*. ICF Consulting Services Limited and Fraunhofer ISI

CIF (Climate Investment Funds) website Industry Decarbonization Program | Climate Investment Funds

City of Nottingham (2017), The Lighthouse Project Cooperation Manifesto. Available at: LighthouseProjectsCooperationManifestoSigned.pdf

Cordonnier, J. and D. Saygin (2023), "Financing solutions to foster industrial decarbonisation in emerging and developing economies", OECD Environment Working Papers, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/24a155ab-en.

Country Comparisons: Gini Index coefficient - distribution of family income available at: Gini Index coefficient - distribution of family income Comparison - The World Factbook

Current World Population available at: World Population Clock: 8.2 Billion People (LIVE, 2024) - Worldometer

D'Arcangelo, F., et al. (2022), "A framework to decarbonise the economy", OECD Economic Policy Papers, No. 31, OECD Publishing, Paris, https://doi.org/10.1787/4e4d973d-en.

Das, A., Ghosh, A. (2023), Vision Net Zero: A review of decarbonisation strategies to minimise climate risks of developing countries. Springer

Denton, F., K. Halsnæs, K. Akimoto, S. Burch, C. Diaz Morejon, F. Farias, J. Jupesta, A. Shareef, P. Schweizer-Ries, F. Teng, E. Zusman (2022), *Accelerating the transition in the context of sustainable development*. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA.

Falcone, P.M. (2023), *Sustainable, Energy Policies in Developing Countries: A Review of Challenges and Opportunities*. Energies.

GDP Data available at: GDP (current US$) | Data

Ge, J., Sumedha B., Jingjing Z., Nan Z., *Mobilizing Key Stakeholders to Accelerate Climate-Tech Innovation*, Berkely Lab.

Ghorbani A., Fartash K., (2023), "*Challenges of Smart Grid Technology Deployment in Developing Countries*," Springer Books, in: Michel Fathi & Enrico Zio & Panos M. Pardalos (ed.), Handbook of Smart Energy Systems, pages 2551-2572, Springer.

Giuzio, G. F., Barone G., Olympios A. (2024), *Integration of Renewable Energy Technologies and Innovative Strategies for Smart Resilient and Flexible Communities*. Integration of Renewable Energy Technologies and Innovative Strategies for Smart, Resilient and Flexible Communities | Frontiers Research Topic

Gupta R., Malik D., Sankhe S., Unni N. (2022), Decarbonising India: Charting a pathway for sustainable growth. McKinsey Sustainability Decarbonising India: Charting a pathway for sustainable growth | McKinsey

IEA (2020), Clean Energy Innovation, IEA, Paris. Available at: https://www.iea.org/reports/clean-energy-innovation

IEA (2020), Energy Technologies Perspectives: Special Report on Clean Energy Innovation Accelerating technology progress for a sustainable future. Available at: Energy Technology Perspectives 2020 - Special Report on Clean Energy Innovation

IEA (2024), ETP Clean Energy Technology Guide. ETP Clean Energy Technology Guide – Data Tools - IEA

IEA (International Energy Agency) (2019), "*Energy Technology Innovation Partnerships*".

IEA (International Energy Agency) (2020), "*Clean energy technology innovation and the vital role of governments*."

IEA (International Energy Agency) (2021), "*Financing Clean Energy Transitions in Emerging and Developing Economies*".

IEA (International Energy Agency) (2024), Policies database. Available at: Policy database – Data & Statistics - IEA

IEA (International Energy Agency), (2021), "*It's time to make clean energy investment in emerging and developing economies a top global priority*.". Available at: It's time to make clean energy investment in emerging and developing economies a top global priority - News - IEA

IEA (International Energy Agency), (2023), "*Unlocking Smart Grid Opportunities in Emerging Markets and Developing Economies*."

IEA, (revised version 2021), Energy Technology Perspectives 2020. Available at: Energy Technology Perspectives 2020

IEA, Innovation and Energy System available at: Innovation - Energy System - IEA

IRENA (2022), IRENA and Partners Define Agenda for Global industrial Decarbonisation. IRENA and Partners Define Agenda for Global Industrial Decarbonisation

IRENA (2023), Innovation landscape for smart electrification: Decarbonising end-use sectors with renewable power, International Renewable Energy Agency, Abu Dhabi.

IRENA (2023), Powering the energy transition with smart electrification. Powering the Energy Transition with Smart Electrification

Kamat A. S., et al., (2023), "Collaborative Industrial Technology Innovation for Clean Energy Transition: Bridging the 'Valley of Death'," T20 Policy Brief

Krishnan M., Samandari H., Woetzel L., Smit S., Pacthod D., Pinner D., Nauclér T., Tai H., Farr A., Wu W., Imperato D. (2022), "*The net-zero challenge: Accelerating decarbonization worldwide*." McKinsey Sustainability Available at: Accelerating decarbonization: The net-zero challenge | McKinsey

Kumar P., (2023) There's rising need for global co-operation to decarbonise industries. In Down to Earth There's rising need for global co-operation to decarbonise industries

Lewis, E., Edwards, R., & Howe, J. (2023). Delivering the Industrial Decarbonisation Challenge: geographical considerations for decarbonisation. Geography, 108(2), 86–94.

McKinsey & Company (2022), "*Decarbonizing the world's industries: A net-zero guide for nine key sectors.*". Available at: Decarbonizing the world's industries: A net-zero guide for nine key sectors | Sustainability | McKinsey & Company

Mishra, R., Singh, R.K. & Gunasekaran, A. (2023), Adoption of industry 4.0 technologies for decarbonisation in the steel industry: self-assessment framework with case illustration. Springer

Mission Innovation (2020), Country Highlights: 5th MI Ministerial 2020. Available at: 3.-MI-Country-Highlights-2020.pdf

Mondejar M., Avtar R., H. L. B. Diaz, Dubey R. K., Esteban J., Gómez-Morales A., Hallam B., Mbungu N. T., Okolo C. C., Prasad K. A., Qianhong She Q., Garcia-Segura S., (2021), "*Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet*". Elsevier.

Number of Intenet Users available at: Internet users - The World Factbook

OECD (2023), *Scaling up climate action: The role of new green industrial policy approaches*. Scaling up climate action: The role of new green industrial policy approaches

Race to zero (2022) "The Breakthrough Agenda: a master plan to accelerate decarbonization of five major sectors." Climate Champions. Available at: The Breakthrough Agenda: a master plan to accelerate decarbonization of five major sectors - Climate Champions

Radhika Khosla *et al.* (2020), Successful clean energy technology transitions in emerging economies. Harvard Kennedy School

S. Yadav, A. Samadhiya, A. Kumar, A. Majumdar, J. A. Garza-Reyes, Sunil Luthra, (2023), "*Achieving the sustainable development goals through net zero emissions: Innovation-driven strategies for transitioning from incremental to radical lean, green and digital technologies*." Volume 197, Elsevier.

Shell India, TERI (The Energy and Resources Institute) (2021), *India transforming to a net-zero emissions energy system*.

Smart Africa website available at: Who we are – Smart Africa

Smart Energy Innovation Fund available at the ADB (Asian Development Bank): Smart Energy Innovation Fund | Asian Development Bank

Smart Energy International, "How IoT revolutionises metering for utilities in developing nations" (2002), How IoT revolutionises metering for utilities in developing nations

Social Republic of Vietnam (2023), Resource Mobilization Plan: Implementing Vietnam's Just Energy Transition Partnership (JETP)

Sovacool B. K., Iskandarova M., Hall J., (2023), "*Industrializing theories: A thematic analysis of conceptual frameworks and typologies for industrial sociotechnical change in a low-carbon future*". Energy Research & Social Science, Volume 97. Elsevier

The Presidency Republic of South Africa (2022), "South Africa's Just Energy Transition Investment Plan (JET IP)"

UN (United Nations) (2021), "*Foundations announce $1 billion fund for renewable in emerging economies".* Department of Economic and Social Affair. Available at: Foundations announce $1 billion fund for renewables in emerging economies | United Nations

UN (United Nations) (2021), Leveraging Energy Action for Advancing The Sustainable Development Goals. Available at: 2021-POLICY BRIEFS_3.pdf

UN (United Nations) (2021), *Theme report on enabling sdgs through inclusive, just energy transitions: towards the achievement of SDG 7 and net-zero emissions*, 2021-twg_3-b-062321.pdf

UN (United Nations), SIDS Lighthouses Initiative (SIDS LHI). Department of Economic and Social Affairs. Available at: SIDS Lighthouses Initiative (SIDS LHI) | Department of Economic and Social Affairs

UNCTAD (UN Trade and Development) (2023), "*Investment policies for the energy transition: Incentives and disincentives*", Issue no. 26. Available at: Investment Policy Monitor, Issue No 26

UNCTAD (United Nations Conference On Trade And Development) (2017), *New innovation approaches to support the implementation of the sustainable development goals*. New York, Geneva, New innovation approaches to support the implementation of the Sustainable Development Goals

UNESCO (United Nations Educational, Scientific, and Cultural Organization), International Centre for Engineering Education (2021), "*Engineering for sustainable development: delivering on the Sustainable Development Goals".* Paris, Beijing.

UNIDO (United Nations Industrial Development Organization) (2023), Industrial Deep Decarbonization Initiative: 2023 Workplan. iddi-workplan-2023-draft.pdf

United Nations Climate Change Technology Committee (2021), Emerging climate technologies in the energy supply sector.

Wankhede, S.K., Paliwal, P., Kirar, M.K. (2021), *Smart Grid Initiatives Towards Sustainable Development: Indian and Worldwide Scenario*. In: Baredar, P.V., Tangellapalli, S., Solanki, C.S. (eds) Advances in Clean Energy Technologies. Springer Proceedings in Energy. Springer, Singapore.

Wazeer A., Das A. (2022), *Recent Developments in Smart Energy Systems*, Springer Nature Switzerland AG.

World Economic Forum (2019), Industry coalitions and alliances: Global Sustainable Energy Innovation Fund (SEIF). Available at: World Economic Forum

World Economic Forum (2020), Stakeholders for a Cohesive and Sustainable World: The Role of Lighthouse Projects. Available at: WEF_Lighthouse_Project_Report.pdf

World Economic Forum (2021), Di Dai, "*Lighthouses boost sustainability with Fourth Industrial Revolution transformation*", Available at: Lighthouses boost sustainability with Fourth Industrial Revolution transformation > Press releases | World Economic Forum

World Economic Forum (2022), Demetrios Papathanasiou, "*These developing countries are leading the way on renewable energy".* Available at: The developing countries leading the way on renewable energy | World Economic Forum

World Economic Forum (2023), Douglas Broom, "*5 smart renewable energy innovations*." 5 renewable energy innovations to fight the climate emergency | World Economic Forum

World Economic Forum (2023), Ewan Thompson, "*The challenges of financing the energy transition in developing economies"*. Available at: The challenges of financing the energy transition in developing economies | World Economic Forum

World Economic Forum (2023), Ewan Thomson, "*Four innovative clean energy-generating solutions*". Available at: Four innovative clean energy-generating solutions | World Economic Forum

World Economic Forum (2023), *Global Lighthouse Network: Shaping the Next Chapter of the Fourth Industrial Revolution*. In collaboration with McKinsey & Company.

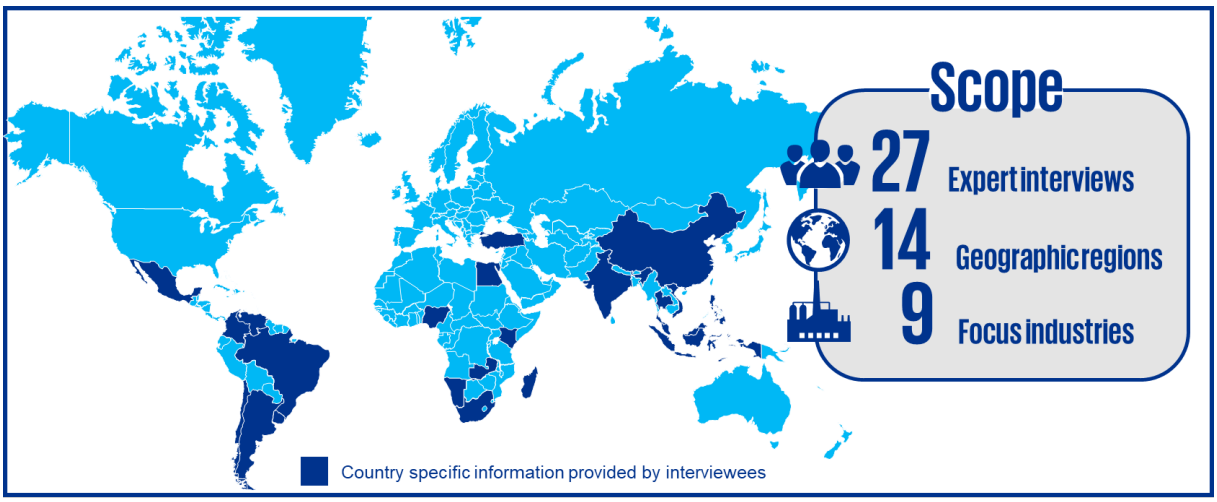
World Economic Forum (2023), *Transitioning Industrial Clusters towards Net Zero: National Policy Enablement for Industrial Decarbonization – Part II*. In collaboration with Accenture

World Resources Institute, Friedrich J., Ge M., Pickens A., Vigna L. (2023), "*This Interactive Chart Shows Changes in the World's Top 10 Emitters*", Available at: World's Top Emitters Interactive Chart I World Resources Institute

5.2.3. Primary data

The findings generated based on the assessment grid will be validated and complemented by primary data. The primary data collected during Phase 1 of the assessment is based on semi-structured expert surveys and interviews, covering geographic/regional insights, industry sectors, expertise in international development, and subject matter expertise in smart energy and industrial decarbonization.

Figure 39: *Scope - expert interviews*



- **Geographic/regional coverage:** To identify regional experts for interviews, the 14 regions as provided by UNSTAT were used. For each region, experts from the KPMG network with in-depth region-specific knowledge of the regulatory and policy landscape, economic factors, and investment environment have been identified.
- **Industry coverage:** Nine critical industries were identified based on their contribution to global GHG emissions and the relevant available technologies within the TRL 3-7 range. These industries included: 1) aluminum, 2) cement and concrete, 3) chemicals and plastics, 4) iron and steel, 5) metallic products, 6) power and utilities, 7) pulp and paper, 8) textiles, and 9) transport. Interviews with experts covering each of these industries were conducted, drawing from the pool of KPMG industry specialists. The list of industries was adapted throughout the assessment as the top five industries per country were identified.
- **International development ex-pertise:** KPMG's International Development Assistance Services (IDAS) practice has close ties with highly influential development organizations and funds such as the UN, the Green Climate Fund, the World Bank, and the large regional development banks. Interviews with at least two senior experts from the IDAS practice have been conducted.
- **Thematic areas expertise:** KPMG's Decarbonization Hub is a global network of experts in climate policy and industry-specific transition pathways and solutions. Conducted interviews involved experts from the Decarbonization Hub, specialized in industrial decarbonization and the energy sector.

Expert interviews

Figure 40: Overview of interview findings

Relevant regions for technological innovation including project foci

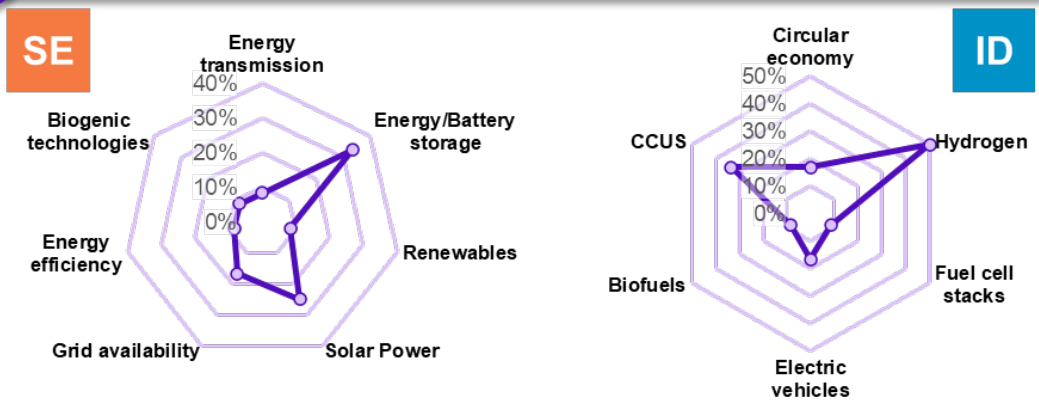
- **Asia:** particularly Southeast Asia, displays significant potential for driving technology and innovation in smart energy. Countries like Indonesia, Malaysia, Thailand, India, the Philippines, and Vietnam are notable examples. Like Africa, rural areas in Asia are targeted for electrification projects.

- **Africa:** Africa shows significant potential in driving technological innovation in Smart Energy (SE) and Industrial Decarbonization (ID), particularly in rural areas where off-grid solutions are needed, significant investments from USAID and the World Bank are focused on electrifying rural communities. Big economies such as Egypt, Nigeria, Kenya, and South Africa naturally attract investments due to their market size and purchasing power.

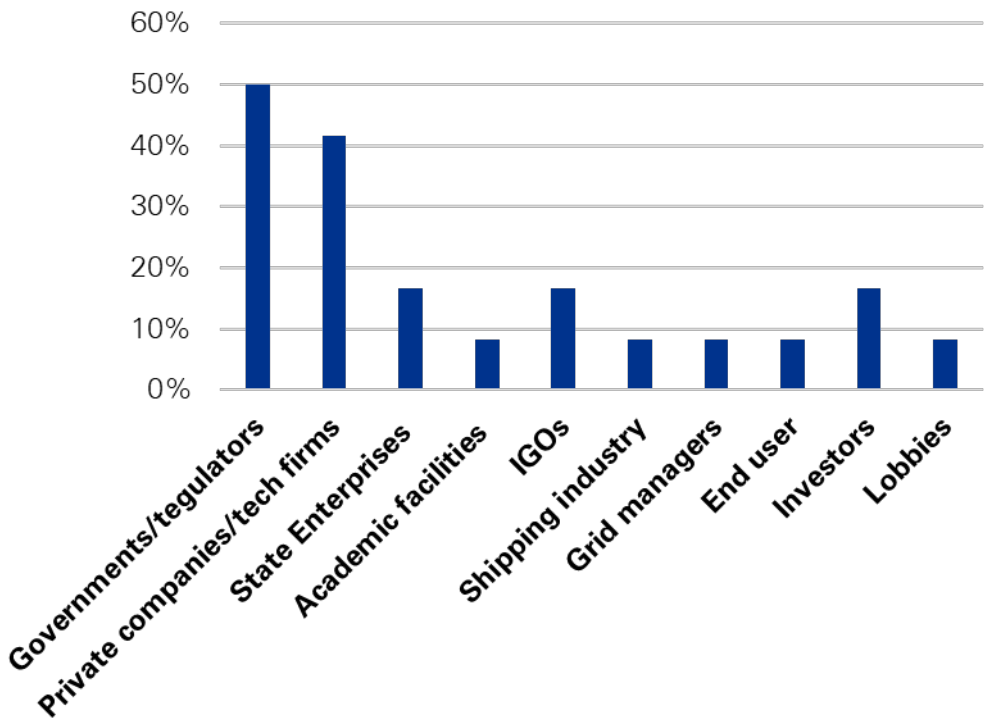
- **South America**: South America, including Mexico and middle-American states, shows significant potential. Brazil, Chile, Uruguay, and Colombia are notable examples, with significant investments in renewables and biofuels.

- **Central and Eastern Europe:** Central and Eastern Europe is advanced in technology transfer and knowledge transfer mechanisms, focusing on energy efficiency mechanisms for industrial decarbonization.

Identified key technologies:



Identified key Stakeholders:



Identified challenges and market constraints:

- Funding and economic viability
- Bureaucratic hurdles
- Policy enforcement
- Regulatory challenges
- Affordability
- Energy security
- Infrastructure readiness
- Market acceptance
- Geographic and non-financial risks
- Talent scarcity
- Capacity building

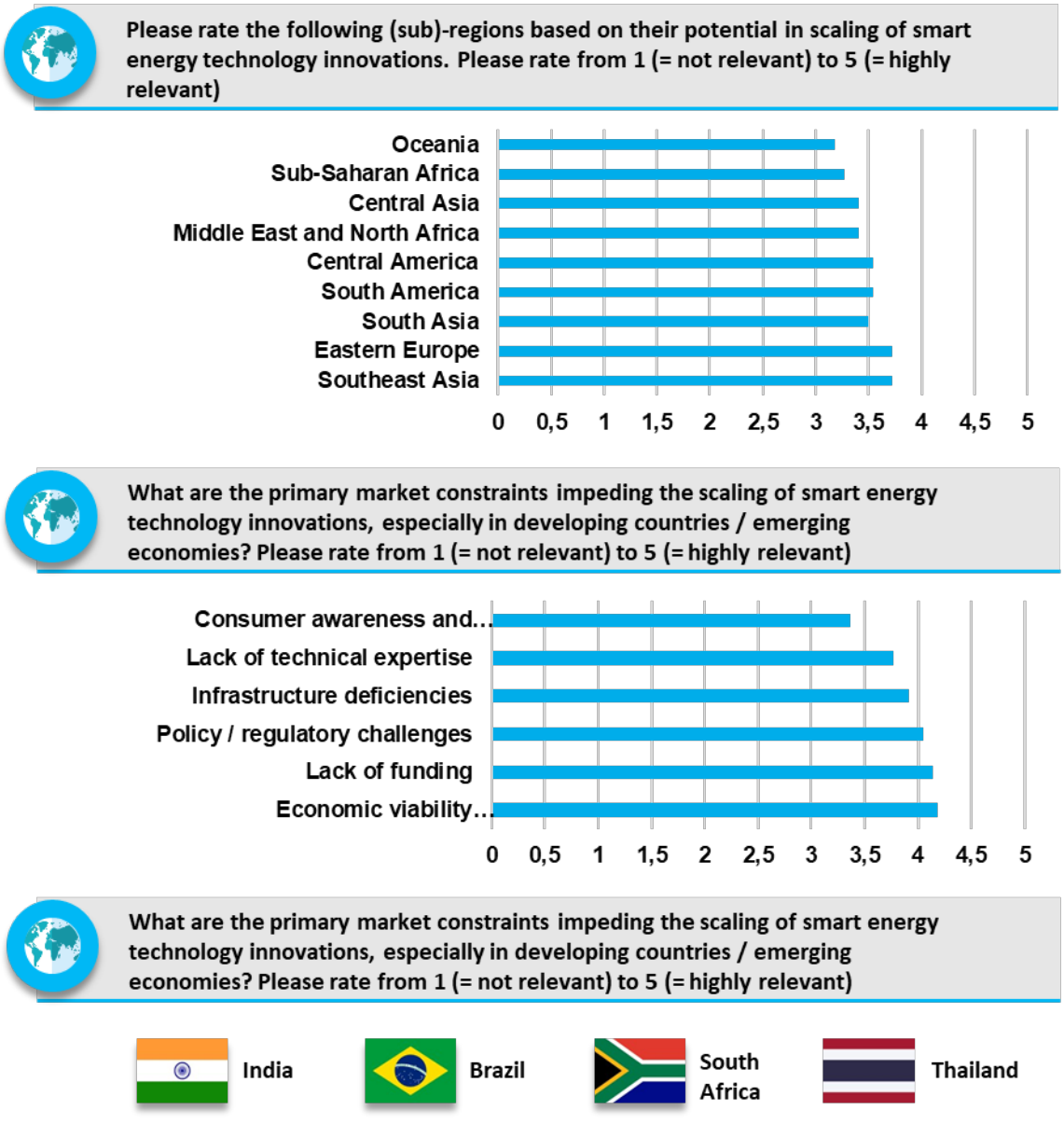
Main Sources for financing and supporting technological Innovation

- **Government Support:** Policy frameworks, incentives, and subsidies.
- **International Investors and Global Organizations:** Funding large-scale projects.
- **Private Sector Contributions:** Investments from private enterprises and technology companies.
- **Development Banks and Specialized Agencies:** Subsidies, grants, and technical assistance from entities like WB, AfDB, ADB, UNIDO, USAID, and FCDO.
- **Climate Funds:** Green Climate Fund for low-emission innovations.
- **Traditional Energy Companies:** Investments in new and innovative technologies – e.g. hydrogen, geothermal, and carbon capture

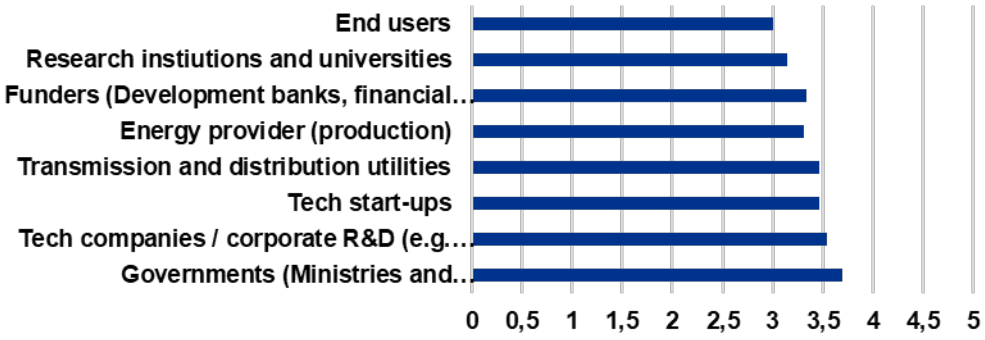
Expert surveys

Furthermore, **two expert surveys**, one for each thematic area, were carried out. To capture the specialized expertise relevant to both thematic areas, the survey focusing on industrial decarbonization engaged the global decarbonization network of KPMG, while the survey on smart energy was directed at experts from the Energy, Natural Resources, and Chemicals (ENRC) group, concentrating on smart energy solutions.

Figure 41: Overview of smart energy survey findings



Which stakeholders of the smart energy landscape have the most impact on the development and use of new technologies? Please rate the relevance on a scale from 1 (= not relevant) to 5 (= highly relevant)



From your perspective, who would benefit the most from innovative smart energy technology projects in developing countries?

- End-user
- Wider local communities (e.g. through job creation)
- State owned companies (e.g. utilities)

Innovations in smart energy can be deployed in different areas of application. Which of the areas mentioned below have the highest potential impact, related to emission reduction, from 1 (= not relevant) to 5 (= highly relevant)

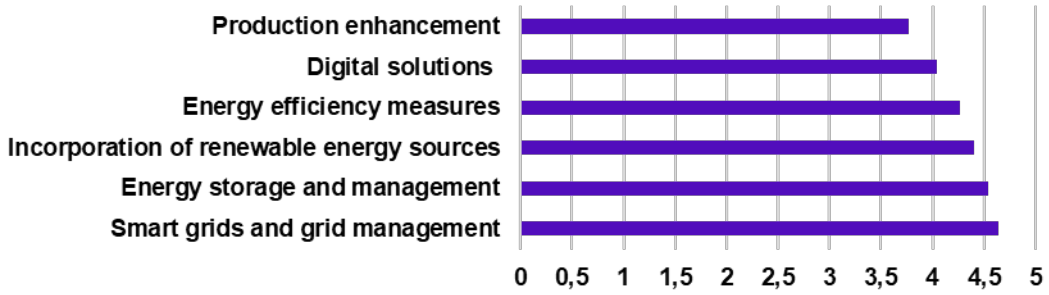
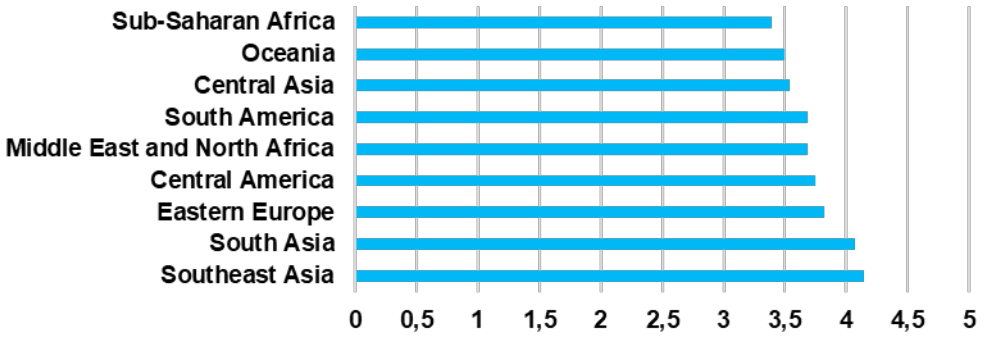
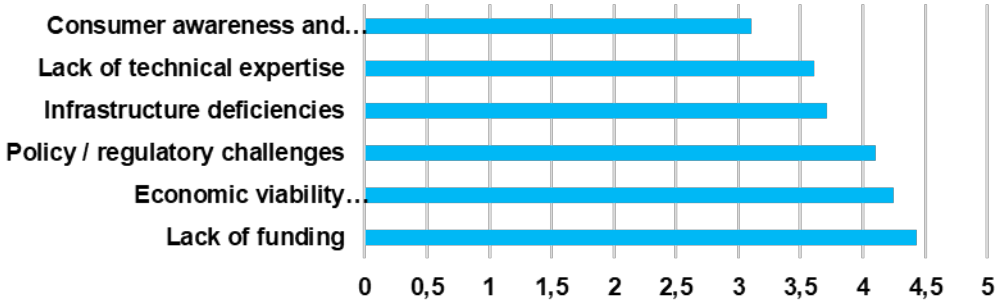


Figure 42: Overview of industrial decarbonization survey findings

Please rate the following (sub)-regions based on their potential in scaling of industrial decarbonization technology innovations. Please rate from 1 (= not relevant) to 5 (= highly relevant)

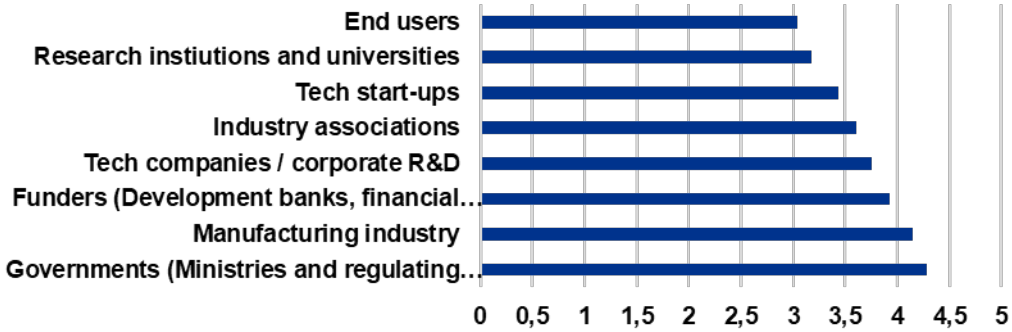


What are the primary market constraints impeding the scaling of industrial decarbonization technology innovations, especially in developing countries / emerging economies? Please rate from 1 (= not relevant) to 5 (= highly relevant)



Which countries have high potential in scaling of industrial decarbonization technology innovations in your view. Please list up to three countries.

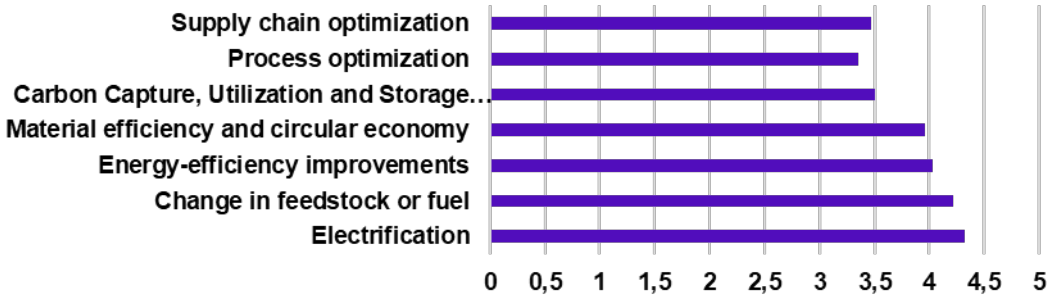
Which stakeholders of the industrial decarbonization landscape have the most impact on the development and use of new technologies? Please rate the relevance on a scale from 1 (= not relevant) to 5 (= highly relevant)



From your perspective, who would benefit the most from innovative industrial decarbonization technology projects in developing countries?

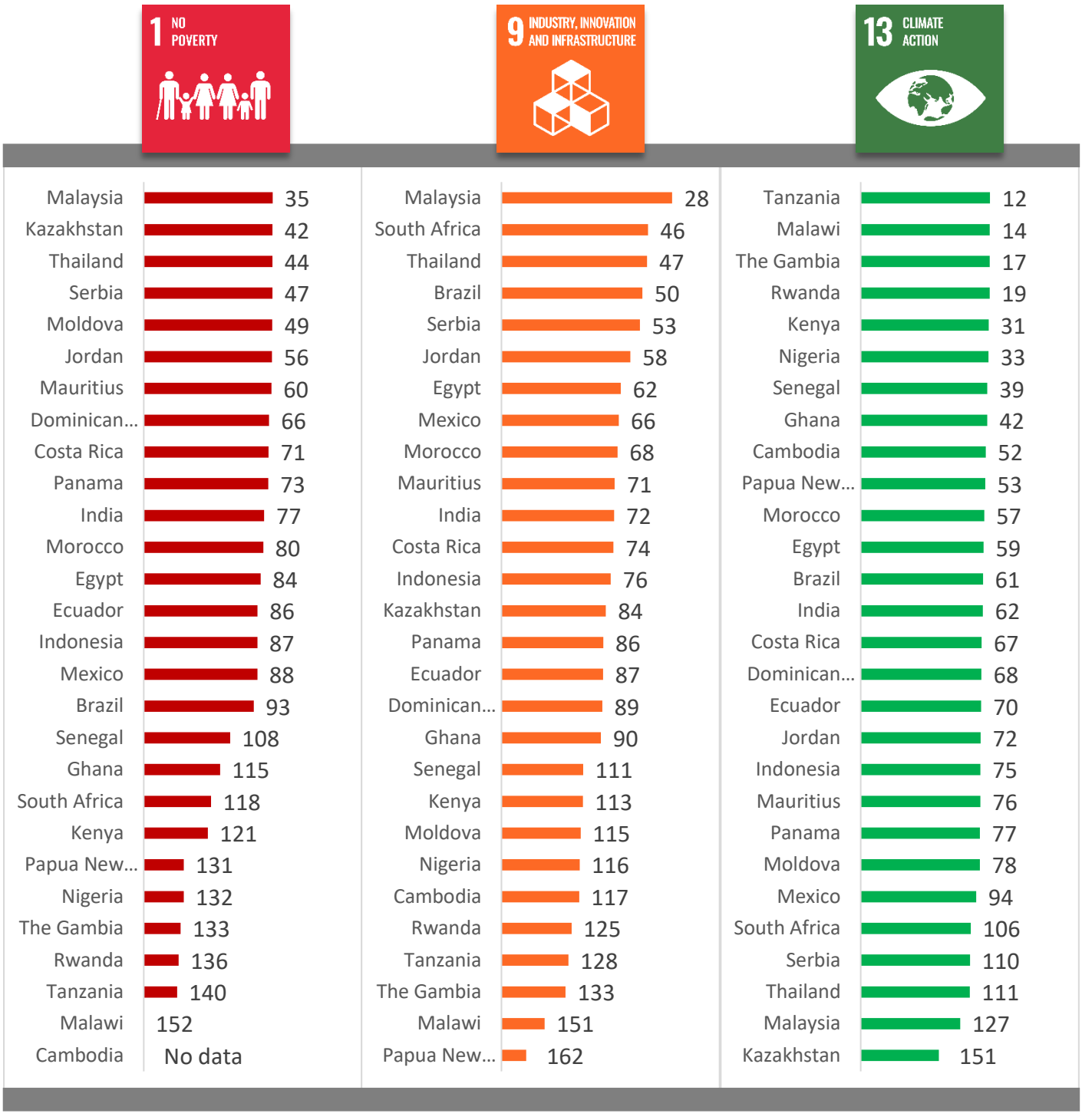
- Governments
- Wider local communities (e.g. through job creation)
- Local private companies

Innovations in industrial decarbonization can be deployed in different areas of application. Which of the areas mentioned below have the highest potential impact, related to emission reduction, from 1 (= not relevant) to 5 (= highly relevant)



Appendix

Ranking of focus country SDG scores



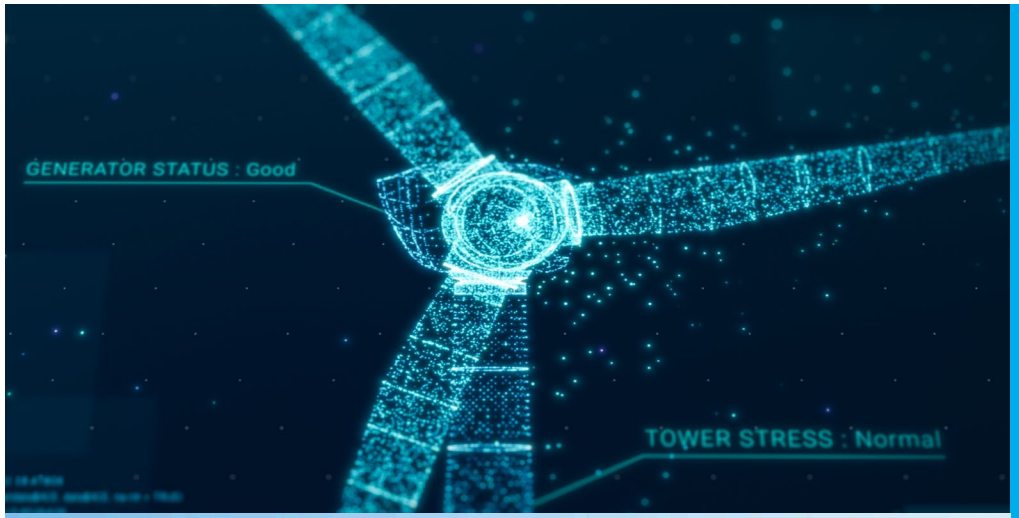
Note: The data bars denote the score (out of 100) allotted to the concerned country in the UN Sustainable Development Report 2024 for the concerned SDG. The countries have been arranged in descending order of their scores. The number outside the bar corresponds to the Global Rank of the country out of all 167 countries covered by the UN report for that particular SDG.

Experts interviewed

Name	Expertise	Date of Interview
Dex Machida	Regional Expert	13.06.2024
Clive Adendorff	Industry Expert	03.07.2024
Erabor Okogun	Industry Expert	26.06.2024
Angela Gildea	Regional Expert	13.06.2024
Felipe Salgado	Regional Expert	19.06.2024
Wei Lin	Regional Expert	06.06.2024
Cherry Hu	Regional Expert	06.06.2024
Jing Li	Regional Expert	06.06.2024
Alex Choi	Regional Expert	19.06.2024
Apurba Mitra	Regional Expert	25.06.2024
Sandeep Chittora	Industry Expert	25.06.2024
Marwa Mahmoud	Industry Expert	19.06.2024
Konrad Witczak	Industry Expert	02.07.2024
Michael Deane	Industry Expert / Subject Matter Expert	26.06.2024
Angus Choi	Industry Expert	17.06.2024
Ugo Platania	Industry Expert	06.06.2024
Franceli Jodas	Industry Expert	26.06.2024
Anish De	Industry Expert	11.06.2024
Mohit Bhasin	Industry Expert	24.06.2024
Jochen Trommer	Subject Matter Expert	10.06.2024
Charbel Moussa	Subject Matter Expert	27.05.2024
Mark Fitzgerald	Subject Matter Expert	27.06.2024
Ruba Amarin	Subject Matter Expert	01.07.2024
Ardy Muawin	Regional Expert	28.06.2024
Leo Mongendre	Subject Matter Expert	03.07.2024
Robert Gilpin	Subject Matter Expert	05.07.2024
Thomas Gaber	Subject Matter Expert	04.07.2024

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D
Accelerate to Demonstrate Facility



Deep dive country profiles

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

India is showing strong commitment to smart energy development with promulgation of various policies, incentives and relatively robust infrastructure

India

Policy	Incentives
• India has strong policy support for different smart energy technologies. Key guiding policy is the "National Smart Grid Mission"	• Incentives exists separately for different type of technology and collectively under smart grid development

Infrastructure	Financing
• India's infrastructure for smart energy is rapidly evolving. Among the selected countries it has the most ongoing projects and initiatives in this area	• Financing remains a critical challenge, but India has been able to receive from organizations like World Bank support for smart grid development

Key Policies and Regulations

National Smart Grid Mission (NSGM)	• Established in 2015, NSGM aims to plan and monitor the implementation of policies and programs related to smart grids. It focuses on modernizing the power sector with advanced metering infrastructure, substation automation, and integration of renewable energy.
Integrated Power Development Scheme (IPDS)	• Launched by the Ministry of Power, IPDS aims to strengthen sub-transmission and distribution networks in urban areas. The scheme includes the deployment of smart meters, IT-enabled energy management systems, and the establishment of reliable communication networks for real-time monitoring and control.
Smart Cities Mission	• Under this mission, several cities are implementing smart grid projects to enhance energy efficiency, reduce losses, and integrate renewable energy sources. This includes the deployment of smart meters, automated demand response systems, and energy storage solutions.

Key Initiatives and collaborations

India Smart Grid Forum (ISGF)	• This public-private partnership aims to accelerate the development of smart grid technologies in India. It focuses on modernizing the power sector through smart meters, advanced communication systems, and grid automation.
U.S.-India Strategic Clean Energy Partnership (SCEP)	• This collaboration includes joint research and development on smart grids and energy storage, as well as new initiatives on carbon capture, utilization, and storage (CCUS) technologies.
Mission Innovation 2.0	• India is part of this global initiative that focuses on accelerating public and private clean energy innovation to address climate change. It includes efforts to decarbonize industrial sectors through advanced technologies and international cooperation.

Key takeaways

- Overall, India has best supportive ecosystem among the selected 28 countries, mainly due to strong policy and incentive support focusing on both smart grid networks and market enablers like VPP and other digital technologies including AI, ML etc.

Source: 1. Policy and Incentives; 2. ISGF; 3. Smart Grids; 4. Smart Grid Mission

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for India and seeing adoption are…

India

Relevant technology types	Most relevant technologies
Cross cutting: Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Digital twin electricity grid

- **Name of the technology:** Digital twin
- **Project description**: The digital twin smart grid project in India is a pioneering initiative led by Panitek Power, in collaboration with BSES Delhi, Venios GmbH, and TERI, and Environment Programme. The project leverages real-time data and advanced analytics to optimize grid operations and improve energy management.
- **Expected impact**: The key outcomes of the projects include grid behaviour predictions for integrating DERs and allow reduction in capex costs as it allows achieving higher capacity on existing assets and deferring infrastructure investments.

02

Brief case study -2 - TPDDL VPP pilot

- **Name of the technology:** Virtual power plant using blockchain
- **Project description**: The TPDDL VPP pilot project aims to create a virtual power plant by aggregating multiple DERs. This involves integrating rooftop solar installations, battery storage systems, and demand response programs into a single, cloud-based platform. The VPP operates as a unified entity, optimizing power generation and consumption across the network.
- **Expected impact**: The desired outcome from the project include Improved grid stability, better integration of renewable energy, and enhanced energy efficiency.

Source: 1. TPDDL; 2. Digital twin

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

India is showing strong commitment to achieve industrial decarbonization with promulgation of various policies, incentives and relatively robust infrastructure

India

Policy	Incentives
• India has multiple sector specific decarbonization policies, along with overarching caps for emissions and clean procurement	• Further incentives exists both in terms of penalties and fiscal support such as Performance Linked Incentives (PLI) for green hydrogen, ammonia and steel

Infrastructure	Financing
• India has made long strides in expanding renewable energy capacity, promoting green hydrogen, CCUS and digital technologies	• Financing remains a critical challenge, but India is leveraging green bonds and international funding to support decarbonization projects

Key Policies and Regulations

Renewable Purchase Obligation (RPO)	• Regulated entities - electricity distribution companies, and large power consumers, like steel and cement industries - are expected to procure a minimum percentage of total consumption of electricity from renewable energy sources.
Perform, Achieve and Trade (PAT) Scheme	• A market-based regulatory instrument (cap-and-trade mechanism) for reducing the specific energy consumption (SEC) of energy-intensive industries by allocating SEC targets and allowing trading of certificates (called Energy Savings Certificate, or ESCert).
Obligations to use non-fossil sources	• The central government can specify energy consumption standards, including mandating a minimum share of energy or feedstock consumption from non-fossil sources. Key sector include industries, transport and buildings.

Key Initiatives and collaborations

Industrial Deep Decarbonization Initiative (IDDI)	• This initiative focuses on transforming heavy-emitting sectors through technological innovation, capacity building, and policy development. This initiative, in collaboration with the UK, aims to promote the use of low-carbon technologies and materials in industries like steel and cement, targeting net-zero carbon emissions by 2050.
Mission Innovation 2.0	• India is part of this global initiative that focuses on accelerating public and private clean energy innovation to address climate change. It includes efforts to decarbonize industrial sectors through advanced technologies and international cooperation.
India-EU Clean Energy and Climate Partnership	• This collaboration focuses on enhancing energy efficiency and integrating renewable energy in industrial processes. It aims to reduce greenhouse gas emissions and promote sustainable industrial practices.

Key takeaways

- Overall, India has one of the best supportive ecosystem among the selected 28 countries, mainly due to strong policy and incentive support focusing on both overarching decarbonization and sector specific goals and strategies

Source: 1. Policy and Incentives; 2. Initiatives; 3. Mission Innovation

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in India are…

India

Key industries	Most relevant technologies
Metals – Iron & steel and aluminum	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and chemical products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Cement and concrete	• CCUS- Chemical absorption of CO_2 using Kilns • Electrification of kilns • Partial use of H_2 in kilns
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks

Key technologies seeing activity in the country

01

Brief case study -1 - Hydrogen based DRI project by IMMT

- **Name of the technology:** Hydrogen based DRI
- **Project description**: The project is being developed by a consortium led by Institute of Minerals and Materials Technology (IMMT). The project involves the use of green hydrogen to reduce iron ore directly, bypassing the traditional carbon-intensive blast furnace route. The hydrogen used in this process is produced through electrolysis, powered by renewable energy sources.
- **Expected impact:** The process aims to achieve more than 90% reduction in emissions, along with increase in efficiency and reduced environment compliance costs.

02

Brief case study -2 - Gasification of biomass IOCL

- **Name of the technology:** Biomass gasification to produce ammonia
- **Project description**: The project is being developed by Indian Oil Corporation Limited (IOCL) in collaboration with various research institutions. Biomass, such as agricultural residues, is converted into syngas (a mixture of hydrogen, carbon monoxide, and carbon dioxide) through gasification. This syngas is then processed to produce ammonia.
- **Expected impact**: The project aims to provide multiple benefits including emission reduction in production of ammonia, decreasing dependency on fossil imports and waste reduction.

Source: 1. IOCL

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Thailand has a well laid smart grid development plan , majorly led by the government owned utilities – EGAT, PEA and MEA

Thailand

Policy	Incentives
• Thailand has well established policy framework to support smart grid development along with roadmap to develop it by 2036	• Incentives exist mostly for smart grid related technologies

Infrastructure	Financing
• Key projects include the establishment of renewable energy forecast centres and demand response control centres by the Electricity Generating Authority of Thailand	• Currently is majorly funded by Thai government which has committed ~USD 5.6 Bn to smart energy projects through 2036

Key Policies and Regulations

Smart Grid Master Plan	• This plan outlines the development of smart grids across Thailand, focusing on enhancing energy security, system reliability, and efficiency. It includes guidelines for integrating renewable energy sources and improving grid management.
Microgrid policies	• These policies support the development of microgrids, particularly in remote areas, by integrating local renewable energy sources. They aim to enhance energy access and reliability through public policy and legal flexibility.

Key Initiatives and collaborations

EGAT Energy Forum	• The Electricity Generating Authority of Thailand (EGAT) hosts this forum to showcase green smart energy solutions and sustainable advancements. The 2023 forum emphasized renewable energy, energy storage systems, and the transition to electric vehicles.
ODA with JICA	• Thailand International Cooperation Agency is working with JICA to provide capacity development for the smart grid networks through both MEA and PEA.

Key takeaways

- Overall, activity and support in Thailand for smart energy development is majorly led by the government institutions and lacks private sector activity compared with other key geographies.

Source: 1. Smart grid policy and roadmap

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key Industries which will enable technology adoption in Thailand are…

Thailand

Relevant technology types	Most relevant technologies
Cross cutting: Cross cutting: charging technologies	• Smart charging • Fast and ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Mae Hong Son Smart Grid Pilot Project

- **Name of the technology:** Smart grid network
- **Project description**: This pilot project aims to enhance the stability and reliability of the power system in Mae Hong Son Province. It includes the implementation of solar PV systems and battery storage to manage energy supply and demand more effectively.
- **Expected impact**: The project aims to improved energy reliability and integration of renewable energy sources, leading to reduced greenhouse gas emissions and enhanced energy security.

02

Brief case study -2 - EGAT & Mitsubishi VPP project

- **Name of the technology:** Vehicle to grid and Virtual power plants (VPP)
- **Project description**: The Electricity Generating Authority of Thailand (EGAT) and Mitsubishi Motors (Thailand) have partnered to pilot V2G technology and test VPP innovation. This project is part of the ERC Sandbox Project Phase 2 and involves the Mitsubishi Outlander PHEV, a plug-in hybrid electric vehicle.
- **Expected impact**: V2G and VPP projects are likely to enhance the grid flexibility and reliability in Thailand.

Source: 1. Smart grid; 2. VPP

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Thailand has strong policy and regulatory support along with ongoing bilateral and regional partnerships focusing on decarbonization of manufacturing industries

Thailand

Policy	Incentives
• Thailand has established a national roadmap for, focusing on key sectors like cement and concrete. The government further is promotive innovative sustainable solutions under Industry 4.0	• The government offers multiple incentives for adoption of greener technologies majorly through tax breaks and subsidies for renewable energy projects

Infrastructure	Financing
• Thailand is investing in infrastructure to support decarbonization, such as (CCS) projects. Collaborations with international companies are helping to develop the infrastructure for large-scale decarbonization efforts	• Financial support comes from both domestic and international sources. Currently its working on multiple collaborations like UNIDO for cement sector , Japanese ministry for CCUS etc.

Key Policies and Regulations

Thailand's Climate Change Master Plan (2015-2050)	• This long-term plan provides a framework for climate change mitigation and adaptation, including strategies for reducing emissions in the industrial sector.
Thailand 4.0 Policy	• This government initiative aims to transform the economy through innovation and technology. It encourages the adoption of clean and renewable energy sources, promotes energy efficiency, and supports research and development in green technologies.
Thailand's Bio-Circular-Green (BCG) Economy Model	• This model integrates bio-economy, circular economy, and green economy principles to promote sustainable development and reduce carbon emissions in industrial activities.

Key Initiatives and collaborations

ASEAN Green Future Project	• This project, involving multiple Southeast Asian countries including Thailand, focuses on accelerating climate actions and decarbonization strategies. It aims to advance domestic climate action through policy opportunities and quantitative assessments.
Decarbonization of Cement and Concrete Sectors	• The Government of Canada and the United Nations Industrial Development Organization (UNIDO) are collaborating with Thailand to decarbonize its cement and concrete sectors. This initiative includes developing a national roadmap, providing technical assistance, and supporting green public procurement targets.
Carbon Capture and Storage (CCS) Partnership	• Japan's Inpex, Thailand's PTTEP, and Japan's JGC Holdings Corporation are exploring the potential for a CCS project in Thailand. This collaboration aims to reduce greenhouse gas emissions and accelerate industrial decarbonization.

Key takeaways

- Thailand has critical supportive ecosystem in place, which provides a stronger support for adoption of industrial decarbonization in the country. Along with presence of multiple multilateral organisation, there is strong financing support in place through ERC sandbox program which provides funding for innovative and critical technology projects.

Source: 1. Thailand's Climate Change Master Plan (2015-2050); 2. Thailand 4.0 Policy

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Thailand are…

Thailand

Key industries	Most relevant technologies
Metals – Iron & steel and aluminium	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks

Key technologies seeing activity in the country

01

Brief case study -1 - Thailand CCUS hub project

- **Name of the technology:** CCUS
- **Project description**: PTT, Thailand's state-owned oil and gas company, is piloting a CCU project to capture CO2 emissions from its industrial processes and convert them into valuable products such as chemicals and fuels.
- **Expected impact**: The project aims to significantly reduce CO2 emissions from industrial processes and contribute to a circular economy by creating valuable by-products.

02

Brief case study -2 - Meranti Green Steel Plant

- **Name of the technology:** Hydrogen based DRI
- **Project description**: Meranti Steel is developing a green steel plant near Map Ta Phut Port in Thailand. The plant will use DRI technology with natural gas, transitioning to green hydrogen when available. The plant aims to produce up to 2 million tonnes per annum of green hot rolled coil (HRC) for both domestic and export markets.
- **Expected impact**: The project aims to become fully carbon neutral over time, significantly reducing CO2 emissions in steel production and supporting Thailand's decarbonization goal.

Source: 1. CCUS hub project; 2. Merati green Steel project

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

South Africa current macroeconomic conditions and ongoing pilot projects makes it an attractive country for smart energy deployment

Policy	Incentives
• Although South Africa has multiple policies including smart grid and technologies as its component it lacks any key central policy or roadmap for smart grid development	• Lacks any specific incentives for smart energy deployment but rather provides incentives based on impact like energy efficiency and renewable projects

Infrastructure	Financing
• South Africa is in the early stages of developing its smart grid infrastructure. Initiatives like the South African Smart Grid Initiative (SASGI) and projects by SANEDI are ongoing	• Financing for smart energy projects is supported by both public and private sectors

Key Policies and Regulations

South Africa's Smart Grid Vision 2030	• This strategic framework outlines the country's goals for developing smart grid infrastructure. It includes modernizing the electricity grid, integrating renewable energy sources, and enhancing grid reliability and efficiency.
Integrated Resource Plan (IRP)	• This plan outlines South Africa's long-term electricity supply strategy, emphasizing the integration of renewable energy sources and smart grid technologies to ensure a sustainable and reliable energy future.
Smart Metering Regulations	• These regulations support the deployment of smart meters across municipalities to improve grid reliability, revenue management, and energy efficiency. They aim to address billing issues and reduce electricity losses.

Key Initiatives and collaborations

South African Smart Grid Initiative (SASGI)	• Launched by SANEDI, this initiative aims to modernize the electricity grid by integrating smart grid technologies. It focuses on improving grid reliability, enabling renewable energy integration, and enhancing customer participation.
Smart Energy Solutions for Africa (SESA)	• This collaborative project between the European Union and nine African countries, including South Africa, aims to provide scalable and replicable energy access technologies. It focuses on decentralized renewables, innovative energy storage systems, and smart microgrids.
Eskom's Smart Grid Initiatives	• Eskom, South Africa's primary electricity supplier, is implementing smart grid technologies to improve grid management and reduce energy losses. These initiatives include advanced metering infrastructure, demand response programs, and grid automation.

Key takeaways

- South Africa has multiple ongoing smart grid initiatives both at national and cities level. This, along with strong policy support and declared ambition create a positive environment to support development of smart energy technologies in the country.

Source: 1. South Africa grid vision; 2. SESA

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in South Africa are…

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Evolve Virtual Power Plant

- **Name of the technology:** Smart grid network
- **Project description**: The project is meant to create an intelligent and interconnected web linking thousands of batteries and solar facilities. The interconnected grid will help the City of Cape Town manage load and demand and provide support services. The solution will also enable electricity exchanges between users at peak hours.
- **Expected impact:** Aggregate hundreds of distributed energy resources in the form of batteries, rooftop solar and have intelligent algorithms enabling efficient management of electricity.

02

Brief case study -2 - Hatfield Digital Twin City (University of Pretoria)

- **Name of the technology:** Digital Twin, AI / ML.
- **Project description:** The Hatfield Digital Twin City project aims to create a smart 3D or digital mirror of the city to improve service delivery. It uses AI and ML to monitor and manage resource flows, including electricity, water, and traffic.
- **Expected impact:** Key benefits include enhanced urban management, improved energy efficiency, and better resource allocation.

Source: 1. Evolve VPP; 2. Hatfield digital twin

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

South Africa has shown strong commitment to achieve industrial decarbonization, with robust policy and incentive structure in place

South Africa

Policy	Incentives
• South Africa has implemented ambitious climate policies, including carbon pricing and the JET Implementation Plan, which outlines interventions and investments needed	• The government offers various incentives for green technologies and renewable energy projects. These include tax rebates and subsidies aimed at reducing emissions and sustainable practices

Infrastructure	Financing
• Significant investments are being made to upgrade infrastructure, particularly in the energy sector, to support decarbonization, including projects for hydrogen and carbon capture etc.	• Financial support comes from both domestic and international sources. Initiatives like the Green Climate Fund and partnerships with global financial institutions provide funding for sustainable projects

Key Policies and Regulations

Integrated Resource Plan (IRP)	• Launched in 2019, this plan outlines South Africa's strategy for electricity generation, aiming to reduce reliance on coal and increase the share of renewable energy sources.
National Energy Efficiency Strategy (NEES)	• This strategy aims to improve energy efficiency across various sectors, including industry, to reduce overall energy consumption and emissions.
National Climate Change Response Policy (NCCRP	• This policy provides a framework for addressing climate change, including measures to reduce emissions and promote sustainable development.

Key Initiatives and collaborations

South African Industrial Energy Efficiency Project (IEE Project)	• Launched in 2010, this project helps industrial companies improve energy efficiency. It focuses on policy development, skill development, and technical support, and is funded by the Global Environment Facility (GEF) and the South African Department of Trade, Industry and Competition.
IDDRI and NBI Collaboration	• The Institute for Sustainable Development and International Relations (IDDRI) and the National Business Initiative (NBI) are working together to support businesses in exploring deep decarbonization pathways for heavy-emitting industries.
Just Energy Transition Partnership (JETP)	• Announced at COP 26, this USD 8.5 billion deal with France, the US, the UK, Germany, and the EU supports a just transition to a low-carbon economy and a climate-resilient society.

Key takeaways

- Overall, South Africa has one of the best supportive ecosystem among the selected 28 countries, mainly due to strong policy and incentive support focusing on both overarching decarbonization and sector specific goals and strategies

Source: 1. Incentives; 2. IEE Project; 3. JETP

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in South Africa are…

Key industries	Most relevant technologies
Metals – Iron & steel and aluminium	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Mining	• Molten oxide electrolysis-based mining • Hydrogen fuelled trucks
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks

Key technologies seeing activity in the country

01

Brief case study -1 - Arcelor Mittal Green Steel Pilot

- **Name of the technology:** hydrogen based DRI
- **Project description:** ArcelorMittal South Africa is exploring the production of green hydrogen directly reduced iron (gHDRI) at its dormant Saldanha Steel Works in the Western Cape. The investigation will focus on using green hydrogen in the Saldanha Works' Midrex process to produce gHDRI, which could be exported or used domestically.
- **Expected impact:** Reduce the embodied carbon in iron and steel production by using hydrogen produced from renewable energy.

02

Brief case study -2 - Anglo American's Hydrogen Truck Project

- **Name of the technology:** fuel cell-based transport
- **Project description:** Anglo American is testing hydrogen-powered trucks at its Mogalakwena platinum mine. These trucks use hydrogen fuel cells to power their engines, replacing diesel and reducing greenhouse gas emissions.
- **Expected impact**: This project aims to demonstrate the viability of hydrogen fuel cells in heavy-duty mining equipment, potentially leading to widespread adoption in the mining industry.

Source: 1. Key sectors in South Africa; 2. Arcelor Mittal Green Steel; 3.Anglo American Hydrogen Truck Project

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Although Mexico has well defined policy and regulations , it lacks key incentives for smart energy deployment

Policy	Incentives
• Mexico has strong policy support for smart grid deployment in the country which exists both in terms of policy and law	• Country currently lacks any key incentives for smart grid deployment

Infrastructure	Financing
• Most of the current effort is focussed on deploying smart meters and other supporting infrastructure for smart grids, which forms important part of new smart grid development	• Direct financing from government is not well defined and country overall has limited financial availability. Lack of presence of any multilateral organisation also impacts financing

Key Policies and Regulations

Smart Grid Implementation Plan	• Developed by the Ministry of Energy, this plan outlines the priorities and strategies for deploying smart grid technologies across Mexico. It aims to modernize the electricity grid, improve system reliability, and support the integration of renewable energy.
National Smart Grid Program	• This program focuses on the deployment of smart grid technologies to meet Mexico's clean energy goals. It includes measures to improve grid management, enhance cybersecurity, and increase consumer participation.
Electricity Industry Law (2014)	• This law reformed Mexico's electricity sector, promoting competition and enabling private investment in smart grid projects. It supports the development of a more efficient and resilient grid infrastructure.

Key Initiatives and collaborations

Smart Grid Mexico	• This non-governmental organization promotes the development and implementation of smart grid technologies to increase energy efficiency. It fosters collaboration between research institutions, industry, and public and private sectors to address economic, social, and environmental challenges.
21st Century Power Partnership	• In collaboration with various Mexican energy authorities, this initiative accelerates next-generation power system planning. It supports grid integration, distributed generation, and smart grid technologies.

Key takeaways

- In Mexico, the smart energy ecosystem is mainly supported by strong policy support and a well-defined roadmap for smart grid deployment.

Source: 1. NREL; 2. WRI

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in Mexico are…

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

No key project ongoing

- Mexico lacks any smart grid projects as major investments in power grid infrastructure is focusing on grid reinforcement and expansion.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Mexico's focus on industrial decarbonization has been mostly towards increasing efficiency in industrial sector


Mexico

Policy	Incentives
• Mexico lacks strong policy support and any key policy covering promotion of decarbonization technologies in industrial applications	• Mexico lacks key incentives to promote industrial decarbonization

Infrastructure	Financing
• Due to lack of good policy support and incentives country has seen slow adoption of decarbonization technologies	• Direct financing from government is limited . Lack of presence of any multilateral organisation also impacts financing.

Key Policies and Regulations

Energy Efficiency Standards	• Mexico has implemented comprehensive energy efficiency standards, including mandatory efficiency targets and incentives for industries to adopt energy-saving technologies.
Circular Economy Law	• Passed in November 2021, this law aims to promote efficiency in the use of products, services, materials, secondary raw materials, and by-products through reuse, recycling, and transformation. It introduces instruments for individuals and companies to promote their products and activities in line with circular economy principles.

Key Initiatives and collaborations

Industrial Decarbonization Accelerator	• This initiative provides technical assistance, training, and financial support to enhance energy efficiency in Mexico's industrial sector, aiming to reduce energy consumption by up to 41% by 2050.
CIF Industry Decarbonization Program	• This program, launched by the CIF, aims to help developing countries, including Mexico, decarbonize hard-to-abate industries such as iron and steel, cement, chemicals, and petrochemicals.
ACT-DDP pilot project	• This international pilot initiative aims to accelerate the implementation of deep decarbonization strategies in Mexico's power generation, cement production, and urban passenger transport sectors.

Key takeaways

- Mexico lack critical policy and supporting ecosystem which has resulted in low uptake of industrial decarbonization technologies.

Source: 1. Industrial energy accelerator; 2. Circular economy law; 3.Industrial decarbonization accelerator; 4.CIF; 5. Energy efficiency standards; 6. IDDRI

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Mexico are…

Key industries	Most relevant technologies
Metals – Iron & steel and aluminium	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Sector agnostic technologies	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation

Key technologies seeing activity in the country

01

Brief case study -1 - Activo Integral Aceite Terciario del Golfo

- **Name of the technology:** CCS for power generation
- **Project description**: This pilot project involves generating electricity with minimal emissions by capturing and storing CO_2. The project is a collaborative effort between PEMEX and other companies, focusing on the feasibility and potential applications of CCS technology.
- **Expected impact:** Reduction in CO_2 emissions from power generation, advancement of CCS technology, and potential scaling up for broader applications.

Source: 1. Key industries; 2. CCS

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Although Egypt has well defined policy and regulations , it lacks key incentives for smart energy deployment

Egypt

Policy	Incentives
• Egypt has strong policy support for smart grid deployment in the country which exists both in terms of policy and law	• Country currently lacks any key incentives for smart grid deployment

Infrastructure	Financing
• Most of the current effort is focussed on deploying smart meters and other supporting infrastructure for smart grids	• Direct financing from government is not well defined and country overall has limited financial availability

Key Policies and Regulations

Integrated Sustainable Energy Strategy (ISES) 2035	• This strategy aims to increase the share of renewable energy in Egypt's energy mix and modernize the electricity grid with smart grid technologies. It focuses on enhancing energy security, efficiency, and sustainability
Egyptian Smart Grid Initiative	• Launched by the Ministry of Electricity and Renewable Energy, this initiative focuses on deploying smart grid technologies to enhance grid management, reduce losses, and integrate renewable energy sources
Electricity Industry Law (2014)	• This law reformed Mexico's electricity sector, promoting competition and enabling private investment in smart grid projects. It supports the development of a more efficient and resilient grid infrastructure.

Key Initiatives and collaborations

Egyptian Electricity Holding Company and Schneider Electric	• EEHC is transforming Egypt's electricity grid into the Middle East's first-ever smart grid with Schneider Electric. This project includes building control centers, installing smart ring main units, and upgrading distribution points and substations
Egyptian-Germany Collaboration	• This collaboration focuses on enhancing Egypt's energy efficiency and integrating renewable energy sources. It includes advancing the Digital technologies of the electricity grid and supporting the implementation of the National Climate Change Strategy 2050
National Smart Grid Program	• Egypt's strategic plan to modernize its power grid includes integrating renewable energy, improving grid reliability, and enhancing energy efficiency. This program supports the country's goals for sustainable energy development

Key takeaways

- Egypt has a well-defined roadmap that focusses on developing smart grid in the country, along with a law that mandates the industry to upgrade to smart grid. Further, it has multiple ongoing collaboration with organisation like GIZ to develop smart energy technologies in the country

Source: 1. EEHC; 2. WSEA; 3. Smart grid

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in Egypt are…

Relevant technology types

- Cross cutting: charging technologies
- Smart grid networks
- Smart grid enabler– market mechanisms
- Digital technologies
- Cross cutting: tracking and monitoring

Most relevant technologies

- Smart Charging
- Fast and Ultra-fast charging
- Inductive charging

- High Temperature Low Sag Conductors (HTLS)
- Voltage source converters
- Synchronous Condenser

- Virtual power plants
- EV demand response
- Industrial demand response for frequency balancing and voltage control

- Digital Twin
- Distributed ledger technology / Blockchain
- AI and ML in distribution grid

- Automated and connected vehicles (level 4+)
- Advanced monitoring technologies
- Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Hitachi ABB Power Grids-EETC Grid Stabilization Project

- **Name of the technology:** Static Var Compensators (SVC) and / or Static Synchronous Compensators (STATCOMs)
- **Project description**: Hitachi ABB Power Grids-Egyptian Electricity Transmission Company (EETC) Grid Stabilization Project represents a strategic collaboration aimed at enhancing the stability and efficiency of Egypt's electricity grid. The project involves the implementation of Static Var Compensators (SVC) and / or Static Synchronous Compensators (STATCOMs).
- **Expected impact:** Key benefits include enhanced grid stability and increasing renewable energy integration.

Source: 1. Hitachi

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Egypt lacks critical policy and regulatory support which has resulted in low uptake of industrial decarbonization technology

Egypt

Policy	Incentives
• Although Egypt has specific decarbonization policies these lack sector specific focus and any detailed roadmap to achieve the ambition	• Incentives are mostly available for renewable adoption. No explicit incentives is available for industry specific technologies

Infrastructure	Financing
• Limited projects uptake in the country, mostly due to lack of well-defined action plant and experience with decarbonization technologies	• Most of the ongoing projects and initiatives seem to be supported by external organisation and lack critical government support

Key Policies and Regulations

Energy Efficiency Standards	• Egypt's government has outlined a comprehensive strategy to reduce greenhouse gas emissions across various sectors, including industry. This strategy includes promoting energy efficiency, renewable energy adoption, and sustainable industrial practices.
National Energy Efficiency Action Plan	• The NEEAP sets specific goals and actions to improve energy efficiency across various sectors, including industry. By reducing energy consumption, the plan contributes directly to the reduction of greenhouse gas emissions from industrial activities.
Egypt's Integrated Sustainable Energy Strategy (ISES) to 2035	• Provides comprehensive approach to sustainable energy development, including aspects relevant to industry such as energy efficiency and the transition to cleaner energy sources.

Key Initiatives and collaborations

Green Sustainable Industry Scheme	• Supported by the European Investment Bank (EIB) and the European Union, this scheme provides financing to help Egyptian companies cut pollution, improve energy efficiency, increase renewable energy use, and scale up circular economy practices.
Climate Investment Funds (CIF) Industry Transition Programme	• This program includes significant investments in green hydrogen projects in Egypt, aiming to support the transition of the industrial sector to low-carbon technologies.
The Sustainable Recycling Industries (SRI) Project	• In collaboration with the Swiss government, this initiative focuses on developing sustainable, circular economic practices within industries, including the reduction of industrial waste and emissions.

Key takeaways

- Although Egypt has good industrial presence it lacks clear ambition for decarbonization along with support for critical technologies needed to reduce emissions across the industry.

Source: 1. CIF

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Egypt are…

Egypt

Key industries	Most relevant technologies
Metals – Iron & steel and aluminium	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Sector agnostic technologies	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1 - NoNSToP project

- **Name of the technology:** Nanofluid based solar PV / T technology for polygeneration
- **Project description**: The Project is led by National Research Institute of Astronomy and Geophysics (NRIAG) and funded by Newton Fund and it aims to develop a cost effective, polygenerating (power, heat and cooling) solar concentrating PVT system able to deliver electrical power up to 3 times higher than an equivalent non-concentrating panel and heat at >120 °C.
- **Expected impact:** The project aims to demonstrate that the technology can be used to deliver cheaper and efficient energy.

Source: 1. NoNSToP

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Cambodia's energy market is developing with support from major international development banks with more focus to mature renewable energy technologies

Cambodia

Policy	Incentives
• Lacks any key policy to drive smart grid or smart energy technologies deployment in Cambodia. Just has overarching policies like energy efficiency or adoption of renewables etc.	• No key incentives are available for smart grid deployment and also nothing for specific smart energy technologies, initiatives exist in form of tax breaks for green technology

Infrastructure	Financing
• Cambodia lacks any smart grid project or specific initiative focusing on smart grid deployment, current focus is towards introduction of BESS systems, and these are major projects	• Significant funding for projects comes through international development banks such as ADB, World Bank, but these focus mainly on mature technologies

Key Policies and Regulations

Energy Technology Roadmap	• This policy promotes sustainable industrial development by encouraging energy efficiency and the use of clean technologies. It aims to modernize the industrial sector, improve regulatory frameworks, and support small and medium-sized enterprises (SMEs) in adopting green practices.
National Energy Efficiency Policy (NEEP)	• This policy focuses on improving energy efficiency across all sectors, including industry. It sets targets for reducing energy consumption and promotes the adoption of energy-efficient technologies and practices to lower emissions and operational costs.
Power Development Masterplan (2022-2040)	• This masterplan aims to ensure reliable and affordable electricity supply, reduce dependency on energy imports, and increase the share of clean energy

Key Initiatives and collaborations

ASEAN Power Grid	• Supported by the Asian Development Bank (ADB), this initiative aims to enhance green energy security across the ASEAN region. It involves the integration of smart grid technologies to facilitate efficient energy distribution and management.

Key takeaways

- Overall, Cambodia is currently lacking major government support for smart energy deployment mainly due to lack of basic infrastructure which is still being developed through support of multilateral technologies

Source: 1. Energy tech roadmap; 2. National Energy Efficiency Policy (NEEP); 3. PDP

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in Cambodia are…

Cambodia

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

No key project ongoing

- Cambodia lacks any smart grid projects as major investments in power grid infrastructure is focusing on grid reinforcement and expansion.
- For other smart energy technologies, since most of these require basic infrastructure, they haven't seen much adoption in the country which is still lacking compared to other countries in the region.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Cambodian industrial sector has multiple ongoing initiatives, however these are mostly focussed on mature and energy efficiency technologies

Cambodia

Policy	Incentives
• Cambodia has industrial and energy efficiency policies which support industrial decarbonization in the country, however it lacks any overarching or sector specific policies	• It lacks specific incentives for industrial decarbonization technologies instead government provides green practices, such as tax breaks and subsidies for adopting energy-efficient technologies

Infrastructure	Financing
• Current projects focus on improving energy efficiency and integrating renewable energy into industrial processes. And country lacks low maturity technological projects	• Even though currently funding is available through both govt and multilateral organizations it is majorly focussed on more mature technologies

Key Policies and Regulations

Cambodia Industrial Development Policy 2015-2025	• This policy promotes sustainable industrial development by encouraging energy efficiency and the use of clean technologies. It aims to modernize the industrial sector, improve regulatory frameworks, and support small and medium-sized enterprises (SMEs) in adopting green practices.
National Energy Efficiency Policy (NEEP)	• This policy focuses on improving energy efficiency across all sectors, including industry. It sets targets for reducing energy consumption and promotes the adoption of energy-efficient technologies and practices to lower emissions and operational costs.
Cambodia's Long-Term Strategy for Carbon Neutrality (LTS4CN)	• This strategy aims for carbon neutrality by 2050 and outlines priority mitigation actions across various sectors, including industry. It emphasizes energy efficiency, renewable energy adoption, and low-carbon technologies to reduce greenhouse gas emissions.

Key Initiatives and collaborations

Japan-Cambodia Cooperation on Low-Carbon Technologies	• This bilateral collaboration involves the transfer of low-carbon technologies from Japan to Cambodia. It includes projects that introduce energy-efficient machinery and renewable energy solutions in various industrial sectors.
Clean Energy for Industry (CEI) Program	• implemented by the Ministry of Industry, Science, Technology, and Innovation (MISTI) in collaboration with international partners, this program focuses on integrating clean energy solutions into industrial processes. It includes initiatives like solar power installations and energy-efficient machinery upgrades.
Cambodia Climate Change Alliance (CCCA)	• This multi-donor initiative, coordinated by the Ministry of Environment, supports various projects aimed at enhancing climate resilience and reducing emissions across different sectors, including industry. It provides funding and technical assistance for implementing low-carbon technologies and practices.

Key takeaways

- Overall, Cambodia has been able to create a supportive ecosystem for industrial decarbonization, mainly supported by ongoing partnerships and initiatives by multilateral organizations. However, country's macroeconomic conditions and

Source: 1. LTS4CN; 2. NEEP; 3. CCCA

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Cambodia are…

Cambodia

Key industries	Most relevant technologies	Key technologies seeing activity in the country
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)	
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks	
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process	

No key project ongoing

- Cambodia lacks any industrial decarbonization projects as country lacks any major industrial sector, the decarbonization focus currently is mostly limited to decreasing emissions from power production.
- Only relevant industry in the country is textile where the decarbonization efforts are focused on switching to renewable energy for energy use.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Morocco's legislative framework for smart grid development is comparatively less mature and activity is major driven through multilateral organizations

Morocco

Policy	Incentives
• Lacks any key policy to drive smart grid or smart energy technologies deployment in Cambodia. Just has overarching policies like energy efficiency or adoption of renewables etc.	• The country also lacks any incentives to smart energy or smart grid systems in the country

Infrastructure	Financing
• There are 2 ongoing projects in the country focusing on deployment of smart grid with support from multilateral organizations	• Funding support is mainly from multilateral; organization which are supporting deployment of clean energy technologies in the country

Key Policies and Regulations

Law No. 13-09 on Renewable Energy	• Enacted in 2010, this law provides a legal framework for the development of renewable energy projects. It supports the deployment of smart grids to facilitate the integration of renewable energy sources into the national grid.
National Low Carbon Strategy 2050	• Launched by the Moroccan government, this strategy aims to achieve net-zero emissions by 2050. It includes comprehensive measures to reduce greenhouse gas emissions across all sectors, including industry, by promoting renewable energy, energy efficiency, and sustainable practices.

Key Initiatives and collaborations

UNIDO and Morocco Partnership	• UNIDO and Morocco have ongoing partnership to drive green industrial development. This includes a new joint initiative on green hydrogen and a roadmap for industrial decarbonization, supported by green funding and a portal for promoting investment in industrial zones.
Industrial Decarbonization Accelerator	• This initiative, supported by various international partners, focuses on enhancing industrial energy efficiency in Morocco. It provides technical assistance and resources to help industries adopt energy-efficient technologies and practices.

Key takeaways

- Overall, major push for industrial decarbonization seems to be coming from global partnerships with organizations like UNIDO, UNEP and EU which provide both technical and funding support to initiatives and projects.

Source: 1. UNIDO; 2. Tatwir; 3. UNEP; 4. UNIDO; 5. decarbonization accelerator

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in Morocco are…

Morocco

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - RADEEMA smart grid project

- **Name of the technology:** Smart grid network
- **Project description**: This project, supported by the U.S. Trade and Development Agency (USTDA), involves a feasibility study to transform Marrakech's power distribution infrastructure into a smart grid. The study will define the technical, economic, and regulatory framework and develop an implementation plan.
- **Expected impact:** The project aims to reduce technical and non-technical losses, decrease the frequency and duration of power outages, and support the integration of renewable energy sources into the grid.

02

Brief case study -1 - Siemens and Atos Smart Metering Project

- **Name of the technology:** Smart energy metering platform
- **Project description**: Siemens and Atos are deploying a smart energy metering platform for the National Office of Electricity and Drinking Water (ONEE). This platform will process data collected from over 100,000 smart meters installed across the country.
- **Expected impact:** The project is expected to optimize energy consumption, improve the management of the national grid, and meet Morocco's growing energy needs.

Source: 1. RADEEMA; 2. Siemens

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Morocco with support from organizations like UNIDO and EU is developing an ecosystem to support industrial decarbonization

Morocco

Policy	Incentives
• Morocco with help from UNIDO has developed a roadmap for decarbonization of steel and cement sectors. However, it lacks any other key policy or regulation for industrial decarbonization	• Although not extensive as other geographies government has provided fiscal incentives for industries especially SMEs to adopt greener practices

Infrastructure	Financing
• Current projects focus on improving energy efficiency and integrating renewable energy into industrial processes. Mostly focusing on highly mature technologies like solar and wind	• Both public and private sectors are actively involved, with significant contributions from international financial institutions like the EBRD and EIB

Key Policies and Regulations

Morocco's Industrial Decarbonization Roadmap	• Developed by UNIDO and Morocco's Ministry of Industry and Trade, this roadmap focuses on deep decarbonization of the steel and cement sectors. It provides clear technological pathways and policy recommendations to support industrial businesses in lowering their emissions.
Tatwir Green Growth Program	• Part of Morocco's 2021-2023 industrial recovery plan, this program supports small to medium enterprises (SMEs) in developing decarbonized processes and products. It provides financial assistance to help SMEs transition to greener practices.
National Low Carbon Strategy 2050	• Launched by the Moroccan government, this strategy aims to achieve net-zero emissions by 2050. It includes comprehensive measures to reduce greenhouse gas emissions across all sectors, including industry, by promoting renewable energy, energy efficiency, and sustainable practices.

Key Initiatives and collaborations

UNIDO and Morocco Partnership	• UNIDO and Morocco have ongoing partnership to drive green industrial development. This includes a new joint initiative on green hydrogen and a roadmap for industrial decarbonization, supported by green funding and a portal for promoting investment in industrial zones.
Industrial Decarbonization Accelerator	• This initiative, supported by various international partners, focuses on enhancing industrial energy efficiency in Morocco. It provides technical assistance and resources to help industries adopt energy-efficient technologies and practices.
Morocco-EU Green Partnership	• This bilateral partnership aims to enhance cooperation on climate action, including industrial decarbonization. It focuses on promoting renewable energy, energy efficiency, and sustainable industrial practices through joint projects and funding.

Key takeaways

- Overall, major push for industrial decarbonization seems to be coming from global partnerships with organizations like UNIDO, UNEP and EU which provide both technical and funding support to initiatives and projects.

Source: 1. UNIDO; 2. Tatwir; 3. UNEP ;4. UNIDO; 5. decarbonization accelerator

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Morocco are…

Morocco

Key industries	Most relevant technologies
Cement and Concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Sector agnostic technologies	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

No key project ongoing

- Morocco lacks any industrial decarbonization projects with **pertaining to innovative technologies** as ~80% of industrial emissions in the country are from cement production, where the major push currently is to replace energy usage from fossil fuel to relatively cheap and clean renewable energy available in the country. Outside key manufacturing industries emission originate from transport sector, where the country has multiple initiatives ongoing.
- Other relevant industry in the country is textile where the decarbonization efforts are focused on switching to renewable energy for energy use.

Source: 1. Key industries by emissions

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Malaysia's smart energy landscape is shaped by robust policy frameworks and a conducive incentive environment

Malaysia

Policy	Incentives
• Malaysia has high level policy frameworks as well as more ground level initiatives that promote smart energy solutions	• Malaysia's Green Investment Tax Allowance covers energy efficiency and renewable energy integration among other green technologies

Infrastructure	Financing
• The key Malaysian energy utility, TNB, has been investing in rolling out smart metering and grid modernization infrastructure	• Financing from the government for smart energy solutions has been present but not much private sector financing has been seen

Key Policies and Regulations

National Energy Policy	• This policy emphasizes the integration of renewable energy and smart grid technologies to enhance energy efficiency and sustainability.
National Energy Transition Roadmap	• Launched in 2023, this roadmap aims to accelerate Malaysia's energy transition, including the integration of energy storage systems to support renewable energy sources. It also has energy efficiency as one its 6 key focus areas.
Smart Cities Program	• The Malaysia Smart Cities Alliance (MSCA) is collaborating with various organizations to develop smart cities. The program focuses on integrating advanced technologies such as smart grids, smart metering, and energy storage solutions to enhance energy efficiency and sustainability in cities.

Key Initiatives and collaborations

MIGHT Smart Grid Initiative	• Led by the Malaysian Industry-Government Group for High Technology, this integrates renewable energy, smart meters, and EV charging stations to enhance grid efficiency and sustainability. It also focuses on policy development and capacity building to support smart grid technologies.
Grid of the Future Program	• Tenaga Nasional Berhad (TNB), the largest electricity utility in Malaysia, is investing around RM27 billion to modernize the national grid. This includes core upgrades, grid refurbishment, and the integration of renewable energy sources.
Advanced Smart Metering (AMI) Rollouts	• TNB has been installing smart meters in Malaysia since 2016, with a goal to equip 9.1 million households by 2026 under its AMI project, which aims to enhance energy monitoring and management. Users can track their electricity consumption in real-time through the myTNB portal and app.

Key takeaways

- Overall, Malaysia has a highly conducive regulatory framework for deploying smart energy solutions along with many on-ground infrastructure rollout efforts by the key energy utility in the country

Source: 1.MIGHT Smart grid initiative 2. Grid of the future program

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in Malaysia are…

Malaysia

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Korea and Malaysia VPP Project

- **Name of the technology:** Virtual Power Plant (VPP)
- **Project description**: A consortium of South Korean utility and technology companies, including Busan City Gas, Shihwa SNC, and I-ON Communications, is partnering with Tenaga Nasional Berhad (TNB) to develop a VPP system.
- **Expected impact:** Key benefits include enhanced grid flexibility and renewable energy integration.

Source: 1. Korea and Malaysia co-pilot virtual power plant system

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Malaysia's industrial decarbonization efforts are complemented by dedicated policy frameworks and infrastructure upgrades

Malaysia

Policy	Incentives
• Malaysia has multiple decarbonization related policies dedicated to specific industries as well as specific decarbonization pathways	• Financing packages and tax incentives are offered for green technology development and process improvement in manufacturing

Infrastructure	Financing
• Green infrastructure particularly large-scale solar parks, hydrogen plants, and CCUS infrastructure is a focus area of many decarbonization policies	• There has been investment by large private corporations such as PETRONAS as well as support from developed countries such as Japan, particularly from JICA

Key Policies and Regulations

Green Technology Tax Incentive	• Various tax incentives are in place for companies seeking to acquire qualifying green technology assets listed under the MyHIJAU Directory (Green Industry Certification). Companies undertaking CCUS for example are eligible for investment tax allowance of 100% for 10 years.
National Energy Transition Roadmap	• Launched in 2023, this outlines a sustainable energy pathway focusing on 6 areas: renewable energy, energy efficiency, hydrogen, bioenergy, green mobility, and carbon capture, utilization, and storage (CCUS) through ten flagship catalyst projects.
I-ESG Framework	• Aims to accelerate the transition towards sustainable practices among manufacturing companies, with four key pillars - standards, financing, capacity building, and market mechanisms - supported by 17 strategies, 50 deliverables, and six key enablers.

Key Initiatives and collaborations

Malaysian Industrial Energy Efficiency Improvement Project	• Initiated in 1999, this aims to enhance energy efficiency in key industrial sectors with support and funding from the UNDP and GEF. It focuses on capacity-building, demonstration projects, and incentive schemes to reduce energy consumption.
ASEAN Green Future Project	• A regional collaboration involving Malaysia, focusing on advancing climate action and decarbonization through research and policy development.
Japan-Malaysia Joint CCUS Feasibility Study	• A collaborative effort between Japan Petroleum Exploration Co., Ltd. (JAPEX) and Petroliam Nasional Berhad (PETRONAS), the study aims to explore the feasibility of CCUS in Malaysia.

Key takeaways

- Overall, Malaysia has a conducive regulatory environment as well as the desired momentum in the private sector to drive innovation, but its financing needs are somewhat addressed by the presence of large private sector companies both from Malaysia and its neighbours such as Korea and Japan

Source: 1 ASEAN Green Future; 2. Japan- Malaysia CCUS Study; 3. Achieving Industrial Energy Efficiency in Malaysia

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Malaysia are…

Malaysia

Key industries	Most relevant technologies
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Metals – Iron & steel	• Conversion of steel off gases to chemicals (blast furnace) • Improved ore refining methods (DRI) • Hydrogen based DRI
Sector agnostic technologies	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation

Key technologies seeing activity in the country

01 Brief case study -1 - Johor Biorefinery Project

- **Name of the technology:** Multiple
- **Project description**: Production of sustainable aviation fuel (SAF) and other biofuels such as renewable diesel or hydrogenated vegetable oil (HVO), to cater to the growing demands of the global aviation and transportation industries.
- **Expected impact:** The project will help reduce dependence on fossil fuels for aviation aligning with significant national policies aimed at enhancing sustainable energy solutions.

02 Brief case study -2 - POSCO Korea – Malaysia CCUS Feasibility

- **Name of the technology:** CCUS
- **Project description**: POSCO Korea-Malaysia CCUS Feasibility Study Project" involves collaboration between POSCO, Malaysia's Petroleum Sarawak Bhd (Petros), and the Malaysian government to explore the potential for developing carbon capture, utilization, and storage (CCUS) solutions in Malaysia.
- **Expected impact:** This project is part of a broader effort to enhance Malaysia's position as a regional hub for carbon capture and storage technologies.

Source: 1. Johor Biorefinery Project; 2. POSCO Korea- Malaysia CCUS Feasibility

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Brazil has undertaken significant initiatives for smart energy integration but faces challenges due to its policy, infrastructure and financial environment

Brazil

Policy

- Although there have been some advances in the Brazilian regulatory structure, many gaps still stand as a barrier to the development of smart grids in the country

Incentives

- White Hourly Tariff (WHT) offers reduced off peak rates and penalties for higher peak hour tariffs. A wider smart meter adoption is important for the success of this tariff structure

Infrastructure

- The deployment of storage technologies is at a slow pace as well as the country's vast size especially remote areas such as the Amazon make it difficult to deploy smart grids

Financing

- High investment costs with limited customer awareness creates an uncertain environment for the utility companies as they need to make the initial investments in the smart meters

Key Policies and Regulations

Smart grid regulation	• It sets standards for smart meter equipment and operational processes making Brazil's grid more efficient and technologically advanced.
Energy compensation system for micro and mini generation	• It aims to enhance the integration and efficiency of distributed energy resources in the national grid.

Key Initiatives and collaborations

Smart grid regulatory roadmap technical assistance project	• The project led by ABRADEE(Brazilian Association of Electricity Distributors) and funded by USTDA(U.S. Trade and Development Agency) aims to analyze the regulatory scenarios to support the implementation of smart grid technologies.
Smart meter integration program	• Copel, a utility company in the Paraná state is advancing its smart meter roll out to modernize the utility infrastructure and enhance service efficiency.

Key takeaways

Future development of smart energy technologies in Brazil hinges on enabling policies, substantial infrastructure funding and the seamless integration of renewable energy sources.

Source: 1. Smart grid challenges in Brazil; 2. Smart meter integration program; 3. Smart Grid Technical Assistance Roadmap

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Brazil and seeing adoption are…

Brazil

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra -fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Planet smart city

- **Name of the technology:** Demand response to information
- **Project description**: Planet smart city has been chosen for a pilot project aiming for energy efficiency through innovative demand response technologies. Key components include the smart meters for real time monitoring and automated demand response systems to adjust usage during peak periods.
- **Expected impact**: The impact includes the reduced energy costs for consumers, improved grid reliability and significant environmental benefits with the increased use of renewable energy sources.

Source: 1. Planet smart city in Brazil; 2. Smart meter pilot

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Brazil is showing strong commitment to achieve industrial decarbonization with promulgation of various policies, incentives and relatively robust infrastructure

Brazil

Policy	Incentives
• The policy framework includes a focus on achieving emission reduction targets with renewable energy expansion and industrial transformation	• MOVER(Green Mobility and Innovation Program) offers fiscal credits companies investing in sustainable technologies

Infrastructure	Financing
• Brazil is a leader in hydropower and biofuels and is now focussing on expanding to other low emission technologies. It has connected numerous small-scale hydropower projects to the grid	• High level of investments required to reach its 2030 GHG reduction goals ,thus it is focusing on international collaborations for decarbonization

Key Policies and Regulations

RenovaBio (Brazil's Biofuel Policy)	• Reduction of carbon emissions by increasing the production and use of biofuels. It focusses on promoting sustainable development through carbon credits for the biofuel producers based on their environmental performance.
National Energy Plan 2050	• Expansion of renewable energy sources, particularly solar and wind to achieve a decarbonized energy sector.
National Policy on Solid Waste	• Establishes guidelines for managing solid waste, promote recycling and environmentally sound disposal practices. It mandates a shared responsibility for life cycle of products ,including specific provisions for managing hazardous wastes.

Key Initiatives and collaborations

Industrial Deep Decarbonization Initiative (IDDI)	• This initiative focuses on transforming heavy-emitting sectors through technological innovation, capacity building, and policy development. This initiative, in collaboration with the UK, aims to promote the use of low-carbon technologies and materials in industries like steel and cement, targeting net-zero carbon emissions by 2050.
Industrial Decarbonization Hub	• Launched by UNIDO and the UK, it supports the country's path to net zero emissions by promoting innovation and collaboration in industrial sectors.. It connects local industries with international partners to drive decarbonization projects through research, policy development and final resources.
National Green Growth Program	• It aims to decarbonize the economy through green investments, sustainable energy initiatives and nature conservation efforts. It is designed to align economic growth with environmental reservation, supporting Brazil's climate commitments.

Key takeaways

Brazil's decarbonization journey is marked by promising international collaborations and innovative solutions, paving the way for a sustainable future

Source: 1. Clean energy innovation in Brazil; 2. Industrial decarbonization Hub; 3. Industrial Deep Decarbonization Initiative; 4. National green growth program

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Brazil are…

Brazil

Key industries	Most relevant technologies
Metals – Iron & steel	• Conversion of steel off gases to chemicals (blast furnace) • Improved ore refining methods (DRI) • Hydrogen based DRI
Cement and concrete	• CCUS- Chemical absorption of CO2 using kilns • Electrification of kilns • Partial use of H2 in kilns
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Mining	• Molten oxide electrolysis-based mining • Hydrogen fuelled trucks
Sector agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation

Key technologies seeing activity in the country

01 Brief case study -1 - FS bioethanol refinery complex

- **Name of the technology:** CCUS, Dissolved CO2 injections
- **Project description**: FS is developing a Bioenergy with Carbon Capture and Storage (BECCS) project at its biorefinery in Brazil. The project will capture CO2 emissions from ethanol production and store it underground, reducing the carbon footprint of biofuel production. This is a part of FS's commitment to sustainability and achieving negative carbon emissions.
- **Expected impact**: The biorefinery will become the first producer of carbon negative ethanol.

02 Brief case study -2 - Aço Verde do Brazil- Carbon neutral steel production

- **Name of the technology:** Carbon substitution with Biomass
- **Project description**: Aço Verde do Brazil operates a steel production facility that leverages sustainable practices to produce carbon-neutral steel. It uniquely utilizes renewable power and circular resource management, including eucalyptus charcoal instead of coking coal, enhancing the sustainability of its operations.
- **Expected impact**: The plant has achieved a significant milestone by becoming the first steel producer to receive a carbon neutral certificate.

Source: 1. FS Biorefinery; 2. AVB carbon neutral steel production

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Limited infrastructure and regulatory challenges hinder Papua New Guinea's smart energy ecosystem

Papua New Guinea

Policy	Incentives
• Although, the country has developed a National Energy Plan, there is still a need for a more comprehensive regulatory support for smart energy technologies	• Lack of incentives for expanding grid or off grid technologies

Infrastructure	Financing
• Grids (including mini grids) in Papua New Guinea lack generation capacity, have limited coverage and a poor quality of service	• Private sector is reluctant to invest in expanding grid or off grid options due to limited incentives, and the lack of policy and regulatory clarity

Key Policies and Regulations

National energy plan (2017-2027)	• It emphasizes upgrading the grid infrastructure to incorporate advanced technologies for improved energy management and reliability.

Key Initiatives and collaborations

Sustainable energy sector development program	• This proposed project from Asian Development Bank (ADB) aims to modernize the country's grid infrastructure with a strong emphasis on integrating renewable energy. This program will support the policy and infrastructure upgrades to reduce reliance on diesel and expand the use of renewable sources.

Key takeaways

By leveraging international collaborations, investments in infrastructure development and a conducive fiscal environment, Papua New Guinea can move closer towards integration of smart energy technologies in the country

Source: 1. Electricity access in PNG 2. Sustainable Energy Sector Development Program

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key technologies which will enable smart energy adoption in Papua New Guinea are…

Papua New Guinea

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultrafast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

No key project ongoing

- Papua New Guinea lacks **innovative smart grid** projects as major investments in power grid infrastructure is focusing on grid reinforcement and expansion.
- For other smart energy technologies, since most of these require basic infrastructure, they haven't seen much adoption in the country.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Papua New Guinea faces policy, financing and infrastructure challenges in its decarbonization efforts

Papua New Guinea

Policy	Incentives
• Although, the country has developed a National Energy Plan, there is still a need for a more comprehensive regulatory support for low emission technologies	• Lack of incentives in Solar PV technologies and other renewable energy and energy efficiency technologies in Papua New Guinea

Infrastructure	Financing
• Rugged terrain and a sparsely distributed population poses challenges for electrification in Papua New Guinea	• Private sector is reluctant to invest in expanding grid or offgrid options due to limited incentives, and the lack of policy and regulatory clarity

Key Policies and Regulations

National energy plan (2017-2027)	• Increasing renewable energy in the energy mix to enhance sustainability and reduce environmental impact.
PNG Development Strategic Plan(2010-2030)	• It aims to increase the renewable energy use, improving energy efficiency and upgrading infrastructure.

Key Initiatives and collaborations

Port Moresby Sustainable Urban Transport Mobility Approaches	• This technical assistance project, supported by the Asian Development Bank (ADB) will assess the feasibility of low emission transport systems and the use of plastic waste in road construction to replace bitumen, thereby promoting a circular economy in the country.

Key takeaways

Papua New Guinea has significant potential for expanding renewable energy due to its abundant resources such as solar and hydro which can be achieved with a stronger policy framework and a favourable financial environment

Source: 1. Electricity access in PNG 2. Port Moresby Sustainable Urban Transport Mobility Approaches

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Papua New Guinea are…

Papua New Guinea

Key industries	Most relevant technologies
Mining	• Molten oxide electrolysis-based mining • Hydrogen fuelled trucks
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1 - Papua LNG CCS project

- **Name of the technology:** CCUS
- **Project description**: TotalEnergies, an energy company based in France will implement a carbon capture and storage (CCS) system for Papua LNG project, aiming to capture and store up to 1.2 million tons of CO2 per year. This initiative is a part of this strategy to reduce carbon footprint of LNG production and enhance sustainability.
- **Expected impact**: Reduction of footprint of LNG production and promoting sustainability, contributing significantly to emission reduction and cleaner energy actions in the region.

Source: 1. Papua LNG CCS project

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Panama's smart energy solutions are hindered by significant upfront costs and regulatory hurdles

Panama

Policy	Incentives
• Although, the country has developed a National Energy Plan, there is still a need for a more comprehensive regulatory support for smart energy technologies	• Lack of incentives for smart grid deployment in the country

Infrastructure	Financing
• Power distribution system suffers from technological limitations, with poor observability and flexibility and it relies on outdated methods	• Unfavorable conditions for investments because of slower adoption rates of smart meters and smart grids in the country

Key Policies and Regulations

National Energy Plan (2015-2030)	• It outlines both short term and long -term goals for increasing renewable energy use, building resilient infrastructure, reduction of fossil fuel usage and a net zero growth plan.
Law on rational and efficient use of energy	• It is a national policy for energy efficiency to improve competitiveness, ease the adoption of energy efficiency measures, promote financing means, and foster new technologies and techniques.

Key Initiatives and collaborations

RELAC ,"Renovables in Latin America and the Caribbean"	• Panama is a part of the Renewables in the Latin America and Caribbean initiative which aims to achieve at least 70% renewable energy in the electricity matrix. It includes 16 member countries and promotes the deployment of energy storage solutions to support the integration of renewable energy sources. The project is supported by Inter-American Development Bank, Global Climate Action Partnership and National Renewable Energy Laboratory.
Rural Panama micro / smart power grid sustainability initiative proposal	• The SES renewables project aims to implement micro and smart power grids in rural Panama to provide clean and sustainable energy to the undeserved communities. In collaboration with U.S. Panama Business Council and PROPANAMA, this project aims to penetrate the clean energy access to local communities.

Key takeaways

Panama can create a favourable smart energy environment by implementing favourable regulations, obtaining necessary investments and enhancing the technical skills

Source: 1. Energy sector of Panama; 2. RELAC ; 3. Micro / Smart Power Grid Sustainability Initiative Proposal

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Panama and seeing adoption are…

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra- fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Fast charging Infrastructure

- **Name of the technology:** Cross cutting: charging technologies
- **Project description**: Evergo,an EV charging network provider is expanding Panama's electric vehicle charging infrastructure by installing high -capacity fast chargers to support the expansion of sustainable transport options in the country.
- **Expected impact**: These new chargers will strengthen the charging infrastructure for electric vehicles in the country and accelerate the country's transition towards clean mobility.

Source: 1. Charging points for electric mobility

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Panama's heavy reliance on hydropower makes its renewable energy sector vulnerable to climate change impacts


Panama

Policy	Incentives
• There is a need for a more elaborate framework to support the decarbonization efforts of the country	• Incentives for renewable energy sources exist but the current PPAs (power purchase agreements), do not incentivize new wind and solar PV projects

Infrastructure	Financing
• The country is heavily reliant on hydropower, thus is vulnerable to climate change. There is a presence of outdated infrastructure requiring maintenance and upgrades	• High upfront costs and investment risks, particularly in the exploration phase for geothermal energy usage

Key Policies and Regulations

Biofuels Law	• It promotes biofuel production and usage to reduce greenhouse gas emissions and fossil fuel dependence. The law includes regulations for blending, incentives for producers and sustainability measures.
National Energy Plan (2015-2030)	• It outlines both short term and long -term goals for increasing renewable energy use, building resilient infrastructure, reduction of fossil fuel usage and a net zero growth plan.
Law on rational and efficient use of energy	• It is a national policy for energy efficiency to improve competitiveness, ease the adoption of energy efficiency measures, promote financing means, and foster new technologies and techniques.

Key Initiatives and collaborations

Urban plastic pollution solutions	• This United Nations Environment Programme (UNEP) led project aims to reduce plastic waste in cities across Panama, Colombia and Jamaica through sustainable solutions and collaborations between the local governments and international partners. This initiative aims to develop better waste management systems, promotion of recycling and encouraging policy changes to reduce plastic pollution in urban areas and build more sustainable cities.
Panama Second Climate Resilience and Green Growth DPL	• This includes reforms to decarbonize transport and energy sector through promotion of clean energy, socially inclusive low carbon growth. This US$ 200 Mn program supports policy foundations towards inclusive transitions, and promoting climate change resilience, while ensuring social equity.

Key takeaways

Diversification of the energy mix and creation of a more conducive incentive and policy environment is crucial for Panama to move towards a cleaner future

Source: 1. Energy sector of Panama; 2. Combating plastic pollution; 3. Panama Second Climate Resilience and Green Growth DPL

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Panama are…

Panama

Key industries	Most relevant technologies
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1 - Panama Canal Decarbonization

- **Name of the technology:** Cross cutting technologies covering electric mobility, renewable energy
- **Project description**: This program aims to strategically decarbonize the Panama Canal operations by implementation of
  - 1. alternative fuels for tugboats and launches
  - 2. Solar PV for electricity generation
- **Expected impact**: This aligns with Panama Canal's vision of making its operations carbon neutral by end of the decade

Source: 1. Panama Canal Decarbonization

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Lack of incentives, climate vulnerability and financial constraints can hamper Moldova's progress towards smart energy integration

Moldova

Policy	Incentives
• The National Development Strategy of Moldova as well the Sandbox Law for innovative solutions focus on integrating smart energy solutions in the country	• The country lacks incentives for smart grid deployment

Infrastructure	Financing
• Moldova is more vulnerable to climate change than the rest of Europe due to weaker adaptative capacity to climate shocks due to its poorer quality of infrastructure	• Moldova has limited financial resources in a complex economic environment, and it cannot finance the most-needed adaptation investments without external support

Key Policies and Regulations

National development strategy	• It emphasises the country's commitment to sustainable development with a significant focus on increasing the share of renewable energy in the energy mix and focus on introduction of smart grids in the country.
Energy efficiency law	• Regulation of activities aimed at reducing the energy intensity of the national economy and the negative impact of the energy sector on the environment by supporting the institutional activity in implementation of programmes, plans other energy consumption efficiency measures specified in law.
Sandbox law for development of innovative solutions in the energy sector	• This law aims to foster innovative smart energy technologies, electric energy storage systems and renewable energy integration.

Key Initiatives and collaborations

Accelerating a just transition in Republic of Moldova	• This initiative is supported by United Nations Development Program, and it aims to accelerate green energy technologies, testing and implementation of innovative technologies(smart grid / metering, energy storage solutions) at regulatory and technological levels, grid modernization, pilot programs for energy diversification and renewable energy integration.

Key takeaways

Stronger incentive framework, a more climate resilient infrastructure and leveraging external financial support are key to Moldova's progress towards smart energy solutions

Source: 1. Climate adaptation in Moldova; 2. Accelerating a Just Transition in the Republic of Moldova Programme ; 3.BESS integration in Moldova

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Moldova and seeing adoption are…

Moldova

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Smart meter pilot program

- **Name of the technology** Smart grid networks
- **Project description**: United Nations Development Program(UNDP) is supporting Moldova's energy system with a pilot program of installing smart meters, enabling efficient energy management and integration of renewable energy sources. The project aims to modernize infrastructure, enhance energy security and improve sustainability.
- **Expected impact**: The smart grid initiative will reduce energy losses, improve grid stability, and facilitate the transition to a greener energy system.

Source: 1. Smart meter pilot program

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Moldova is highly vulnerable to climate change and has a high dependence on energy imports with limited diversification of energy supply sources

Moldova

Policy	Incentives
• The policy environment is still relatively under-developed and can prove as obstacles for attracting investments in commercially viable projects in the renewables sector	• Moldova has established three distinct support schemes depending on the size of the power plant: net metering, feed-in-tariffs, and tendering

Infrastructure	Financing
• Moldova is more vulnerable to climate change than the rest of Europe due to weaker adaptative capacity to climate shocks due to its poorer quality of infrastructure	• Moldova has limited financial resources in a complex economic environment, and it cannot finance the most-needed adaptation investments without external support

Key Policies and Regulations

National Development Strategy	• It emphasises the country's commitment to sustainable development with a significant focus on increasing the share of renewable energy in the energy mix and enhance energy security.
Energy Efficiency Law	• Regulation of activities aimed at reducing the energy intensity of the national economy and the negative impact of the energy sector on the environment by supporting the institutional activity in implementation of programs, plans other energy consumption efficiency measures specified in law.

Key Initiatives and collaborations

Pathways towards Decarbonization of the Transport Sector in Moldova	• Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) supported this project which aims to identify priority areas for decarbonization and project development trends over the next 25-30 years within the transport sector. The overarching project outcome is to provide specific forecasts and assessments of the transport sector aiming on the decarbonization of the transports sector and integrating them into national plannings and actions in Moldova.
Enabling an inclusive green transition in the republic of Moldova	• This initiative supports Moldova's transition to a low emission, sustainable economy by enhancing decision making, building capacities and supporting the pilot green initiatives. It also focusses on renewable energy technologies, innovative sustainable transport and mobility solutions and circular economy principles in new business models.

Key takeaways

Moldova should focus on expanding renewable energy and improving energy efficiency to enhance its energy security and sustainability

Source: 1. Climate adaptation in Moldova; 2. Enabling an Inclusive Green Transition in the Republic of Moldova; 3. Pathways towards decarbonisation of the transport sector in Moldova

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Moldova are…

Moldova

Key industries	Most relevant technologies
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01 Brief case study -1 Green and circular economy promotion program

- **Name of the technology:** While Moldova does not have technology - based projects, they are promoting circular economy which will help in decarbonization
- **Project description:** The Moldovan government approved this program to help reduce carbon emissions by encouraging businesses to adopt sustainable practices, promoting the use of renewable energy sources, enhancing energy efficiency, and implementing circular economy principles to minimize waste and reuse resources.
- **Expected impact**: This program will lead to the promotion of resource efficiency, waste reduction and sustainable economic growth in the country.

02 Brief case study -2 - Clean technology innovation programme for SMEs and start-ups

- **Name of the technology:** While Moldova does not have technology - based projects, they are creating an enabling environment for scaling up clean technology solutions
- **Project description:** This project aims to facilitate Moldova's shift to a low carbon economy, by promoting clean technology innovations and entrepreneurship in SMEs and start-ups through the development of a vibrant cleantech ecosystem to create green jobs and industries.
- **Expected impact**: Reduction of carbon emissions in Moldova while stimulating economic growth through advancements in clean technology and increased competitiveness in SMEs.

Source: 1. Green and circular economy promotion program; 2. Clean technology innovation programme for SME's and startups in the Republic of Moldova

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Costa Rica's smart energy efforts face challenges due to technological gaps and climate related impacts

Costa Rica

Policy	Incentives
• Costa Rica has a policies dedicated to grid modernisation and the integration of smart grids for an efficient supply of energy	• The country lacks incentives for smart grids and smart meters

Infrastructure	Financing
• The country is heavily reliant on hydropower making it vulnerable to climate change	• Lack of incentives for smart energy solutions creates an unfavorable financial environment

Key Policies and Regulations

National Energy Plan	• This plan emphasizes on modernizing the grid infrastructure to enhance efficiency, reliability and integration of renewable energy sources.
National Strategy for Smart Grids	• It aims to modernize the country's electrical grid by integrating advanced technologies for greater efficiency, sustainability and energy security.

Key Initiatives and collaborations

RELAC (RELAC ,"Renovables in Latin America and the Caribbean")	• Costa Rica is a part of the Renewables in the Latin America and Caribbean initiatives which aims to achieve at least 70% renewable energy in the electricity matrix. It includes 16 member countries and promotes the deployment of energy storage solutions to support the integration of renewable energy sources. The project is supported by Inter-American Development Bank, Global Climate Action Partnership and National Renewable Energy Laboratory.

Key takeaways

With dedicated policies and incentives for the use of renewable energy sources, Costa Rica is on track to create a favourable environment for decarbonization

Source: 1. Renewable Energy in Costa Rica; 2. RELAC

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Costa Rica and seeing adoption are…

Costa Rica

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Clean transport project

- **Name of the technology:** Cross cutting - charging technology
- **Project description**:The project plan aims to install 724,000 advanced metering systems to provide charging infrastructure for 185 electric buses. Climate Investment Fund (CIF) providing highly concessional loan of US$ 45 Mn, in Nov 2023.
- **Expected impact**: This project aims to reduce emissions by ~17 kt of COE-eq per year and reduce the operational costs by US$ 1.2 Mn.

Source: 1. Clean transport project

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Costa Rica offers a favourable policy and incentive environment for renewable energy use in the country

Costa Rica

Policy	Incentives
• Costa Rica has a dedicated National decarbonization Plan to achieve net zero emissions through a comprehensive strategy focussed on the use of renewable energy in the country	• The Regulations on the Efficient Use of Energy exempts equipment used for renewable energy from import duties and provides several tax exemptions (e.g. excise tax, ad valorem tax, general sales tax, specific customs tax)

Infrastructure	Financing
• The country is heavily reliant on hydropower making it vulnerable to climate change	• The government's commitment towards sustainable development and the presence of incentives for renewable energy project creates a conducive environment for investments

Key Policies and Regulations

Incentives and promotion for electric mobility	• This law creates the regulatory framework to regulate the promotion of electric transport in the country and strengthen public policies to encourage its use within the public sector and in the general public.,
National Energy Plan	• This law aims to reach the objective of "energy sustainability with low emission levels" and supports the continuation of renewable energy development, energy efficiency and low-carbon emission transport.
National decarbonization Plan	• It aims to achieve net zero emissions by 2050 through renewable energy, sustainable transport and green industries and eco system conservation strategies.

Key Initiatives and collaborations

Ecoins program for circular economy	• This program supports the recycling and circular economy by incentivizing citizens through a technological economic reward scheme. This initiative is a collaboration between public and private sector, and it aims to encourage proper waste management and recycling practices in the country.

Key takeaways

With dedicated policies and incentives for the use of renewable energy sources, Costa Rica is on track to create a favourable environment for decarbonization

Source: 1. Renewable Energy in Costa Rica; 2. Ecoins program for promoting circular economy

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Costa Rica are…

Costa Rica

Key industries	Most relevant technologies
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1 - Accelerating the transition to electric public transport in the Greater Metropolitan Area of Costa Rica

- **Name of the technology:** While Costa Rica does not have technology -based projects, they are promoting circular economy which will help in decarbonization.
- **Project description**: The main goal of the project is to achieve decarbonization in the Greater Metropolitan Area (GAM) through sustainable integrated urban planning. It proposes reforms of obsolete laws, construction of cycle paths and green sidewalks, sustainable mobility and greening of 2,000 hectares, in coordination with local governments of the Greater Metropolitan Area and entities with experience in the field, as well as the promotion of the circular economy.
- **Expected impact**: The project will significantly reduce greenhouse gas emissions and improve air quality by transitioning public transportation in Costa Rica's Greater Metropolitan Area to electric vehicles promoting sustainable urban mobility.

Source: 1. Accelerating transition to electric transport in Costa Rica

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Ecuador is moving towards modernizing its energy networks to enhance efficiency and reliability

Ecuador

Policy	Incentives
• The policy environment for smart energy is supportive and evolving. It has a comprehensive roadmap for smart grid implementation showing its commitment towards creating a sustainable grid	• Lack of incentives for smart grids and smart meter deployment in the country

Infrastructure	Financing
• There is need for further investment in infrastructure to support the expansion and capabilities of the smart grids	• Limited government involvement in implementing smart grid projects in the country

Key Policies and Regulations

Energy Transition Plan	• Under this plan, with support from Inter -American Development Bank, Ecuador will reconfigure its electricity generation mix, optimize energy consumption among end users, overhaul its electricity infrastructure, and transform the Galápagos into "smart islands" through automation and digitalization.

Key Initiatives and collaborations

RELAC (RELAC ,"Renovables in Latin America and the Caribbean“)	• Ecuador is a part of the Renewables in the Latin America and Caribbean initiative which aims to achieve at least 70% renewable energy in the electricity matrix of the region. It includes 16 member countries and promotes the deployment of energy storage solutions to support the integration of renewable energy sources. The project is supported by Inter-American Development Bank, Global Climate Action Partnership and National Renewable Energy Laboratory.
Smart Grids Roadmap	• Under this initiative a road map has been created which aims to modernize the electrical grid by 2030,focussing on real-time operations and efficient energy use. The roadmap includes phases for foundational technologies ,advanced technologies, and applications like microgrids.

Key takeaways

With more investments in infrastructure upgrades and a favourable incentive environment , Ecuador can advance towards implementing smart energy solutions

Source: 1. Renewable energy in Ecuador; 2. Smart grid roadmap in Ecuador; 3. RELAC

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Ecuador and seeing adoption are…

Ecuador

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Smart grid integration

- **Name of the technology:** Smart grid network
- **Project description**: Ecuador's Centrosur has partnered with Gridspertise to modernize and digitalize its distribution network through smart metering and advanced grid infrastructure . The initiative includes developing studies, using technological systems and deploying Gridspertise's smart metering solutions and power quality devices.
- **Expected impact**: It will enhance electricity reliability and efficiency in the country.

02

Brief case study -2 - Fair and inclusive Energy Transition in Ecuador

- **Name of the technology:** Microgrids
- **Project description**: The Inter-American Development Bank(IDB) is supporting Ecuador's energy transition by investing in development of microgrids. The IDB's investment will help integrate renewable energy sources and improve the resilience of country's energy infrastructure.
- **Expected impact**: The initiative will enhance energy access, reliability and sustainability across remote areas in Ecuador.

Source: 1. Fair and inclusive Energy Transition in Ecuador; 2. Smart grid integration

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Ecuador's decarbonization efforts focus on expanding renewable energy, energy efficiency and circularity principles

Ecuador

Policy	Incentives
• The policy environment is conducive to decarbonization in Ecuador driven by a combination of national plans, international commitments and sector specific strategies	• Feed-in Tariff (FiT) exists for non-conventional renewable energy sources (PV, wind, solar thermal, biogas, geothermal) with a capacity below 50M.

Infrastructure	Financing
• The country faces delays in bringing hydropower and other renewable energy projects into operational status	• High upfront costs and lack of access to financing for solar PV and wind energy projects

Key Policies and Regulations

National Energy Efficiency Plan	• This plan focusses on improving energy efficiency across various sectors. It emphasizes on the importance of reducing energy consumption, promoting sustainable practices and the use of renewable energy sources to achieve environmental and economic benefits.
Circular Economy Law	• This law will promote the transition from a linear economy to an inclusive circular economy, and it regulates sustainable production, responsible consumption, and inclusive waste management.

Key Initiatives and collaborations

Global Plastic Action Partnership	• Ecuador joined this partnership with the World Economic Forum to tackle plastic pollution. This initiative aims to reduce plastic waste and promote a circular economy for plastics.
Decarbonization road map for the cement industry	• The Ecuadorian Cement and Concrete Institute (INECYC) recently launched its decarbonization road map in collaboration with FICEM, the Interamerican cement federation. This would help the cement sector to reduce the carbon footprint and support Ecuador's broader efforts to lower carbon emissions.

Key takeaways

Ecuador is advancing its decarbonization efforts by adopting principles and creating a conducive policy environment

Source: 1. Renewable energy in Ecuador; 2. Global Plastic Action Partnership; 3. Decarbonization road map for cement industry

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Ecuador are…

Ecuador

Key industries	Most relevant technologies
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1 - Improving Solid Waste and Inclusive Circular Economy in Ecuador

- **Name of the technology:** While Ecuador does not have technology - based projects, they are promoting circular economy which will help in decarbonization.
- **Project description:** The Inter -American Development Bank supported initiative “Improving Solid Waste and Inclusive Circular Economy in Ecuador” aims to enhance solid waste management in by leveraging South Korean expertise in sustainable waste management technologies.
- **Expected impact**: This initiative will significantly enhance waste management practices and promote environmental sustainability in Ecuador.

Source: 1. Improving solid waste management and inclusive circular economy in Ecuador

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Dominican Republic struggles with an unfavourable policy environment and infrastructure readiness for implementing smart energy solutions

Dominican Republic

Policy	Incentives
• The regulations in Dominican Republic are outdated. There is a need for a more advanced policy framework for accelerating smart grid deployment in the country	• Lack of incentives for smart grid / smart meter deployment in the country

Infrastructure	Financing
• The country struggles with insufficient transmission infrastructure and lack of energy storage solutions	• Lack of clear regulations creates an uncertain investment climate

Key Policies and Regulations

Net metering regulation	• This regulation supports the development of distributed generation by enabling customers to offset their energy consumption and reduce electricity bills and contributes to the overall modernization of the electricity sector.
General Electricity Law	• The law promotes the modernization of the electricity sector by encouraging competition, investment in infrastructure upgrades and setting standards for service quality and reliability.

Key Initiatives and collaborations

RELAC (RELAC ,"Renovables in Latin America and the Caribbean“)	• Dominican Republic is a part of the Renewables in the Latin America and Caribbean initiative which aims to achieve at least 70% renewable energy in the electricity matrix of the region. It includes 16 member countries and promotes the deployment of energy storage solutions to support the integration of renewable energy sources. The project is supported by Inter-American Development Bank, Global Climate Action Partnership and National Renewable Energy Laboratory.

Key takeaways

Robust public-private collaborations and clear regulatory frameworks are key to Dominican Republic’s growth in the smart energy domain

Source: 1. Dominican Republic's Transition to Renewable Energy; 2. RELAC; 3. Technical assistance for energy storage systems

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Dominican Republic and seeing adoption are…

Dominican Republic

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Promoting the energy transition in the Dominican Republic and achieving climate targets

- **Name of the technology:** Micro grids
- **Project description**: With support from the German Agency for International Cooperation, this initiative focusses on expanding renewable energy and battery and storage systems in the country. A key objective of the project includes a pilot project for electricity access in the rural areas with micro grids.
- **Expected impact**: Improved energy access and community engagement in the rural areas.

Source: 1. Promoting the energy transition in the Dominican Republic and achieving climate targets

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Challenges faced by Dominican Republic in its decarbonization pathway includes an outdated infrastructure and limited financial resources

Dominican Republic

Policy	Incentives
• There is a need for a more elaborate framework to support the decarbonization efforts of the country	• The Law on incentives for Development of Renewable Energy Sources and its Special Regimes provides incentives for solar, wind ,hydro and biomass energy projects

Infrastructure	Financing
• The country has insufficient transmission infrastructure for renewable energy integration	• The country struggles with limited access to capital, high perceived risks and insufficient financial tool tailored for renewable energy investments

Key Policies and Regulations

Renewable Energy Law	• This is a law on incentives for the development of renewable energy sources, which aims to increase the diversity of energy sources, reduce dependence on imported fossil fuels and stimulate investment in renewable energy.

Key Initiatives and collaborations

Energy and climate partnership of the Americas	• Dominican Republic is a part of the Energy and Climate Partnership of the Americas, an initiative which promotes the decarbonization of the energy system, transportation, industry, and housing in the Americas, through cooperation for the sustainable production and use of all forms of renewable energy and other low-carbon sources to enhance the sustainable energy development of the region.

Key takeaways

To advance decarbonization in the country, Dominican Republic should focus on enhancing financial mechanisms, upgrading infrastructure and streamlining regulatory processes

Source: 1. Dominican Republic's Transition to Renewable Energy, 2. Energy and Climate Partnership of the Americas

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Dominican Republic are…

Dominican Republic

Key industries	Most relevant technologies	Key technologies seeing activity in the country
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)	
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks	
Cement and concrete	• CCUS- Chemical absorption of CO2 using kilns • Electrification of kilns • Partial use of H2 in kilns	
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)	

No key project ongoing

- Dominican Republic lacks any industrial decarbonization projects with **pertaining to innovative technologies** as the country still relies on imported fossil fuels for nearly all its energy needs. The country is scaling up its renewable energy resources, which can help meet energy demand. Several solar PV plants are under construction in the country along with other renewable energy projects showing its commitment to achieve 25% of its energy needs with renewables by 2025.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Serbia is steadily progressing towards smart energy through smart meter adoption however it still has an outdated infrastructure

Serbia

Policy	Incentives
• The Integrated National Energy Plan of the country has outlined the plans for integration of smart grids, smart meters and battery and energy storage systems in the country	• The Integrated National Energy Plan outlines a policy measure for promotion of demand response for the end-users by use of the dynamic tariff system

Infrastructure	Financing
• The country has an outdated infrastructure and is heavily reliant on coal	• It has the support from European Bank for Reconstruction and Development and EU but financial institutions in Serbia are hesitant to finance renewable energy projects due to perceived risks

Key Policies and Regulations

Integrated National Energy and Climate Plan of the Republic of Serbia

- This plan emphasizes on modernizing the existing grid as well as implementing advance metering infrastructure for real time energy management. Energy storage solutions will also be implemented to balance the demand and supply.

Key Initiatives and collaborations

Smart Metering in Serbia

- This project is lead by Elelktrodistribucija Srbije DOO Beograd, a key player in Serbia's electricity distribution sector and is supported by European investment Bank. It aims for installation of about 1.1 m advanced electricity meters, including the related IT infrastructure, in the period 2023-2026.

Key takeaways

With international support for grid modernization, Serbia can move forward in its journey of implementing smart energy solutions

Source: 1. Smart metering in Serbia

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Serbia and seeing adoption are…

Serbia

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - AI-driven Virtual Power Plant feasibility

- **Name of the technology:** Virtual Power Plants
- **Project description**: This project involves the Slovak Challenge Fund and local partners in Serbia, and it explores the potential of AI driven virtual power plants. It will use AI to measure and predict energy production and consumption, within these virtual groups and assess the readiness of Serbia's electricity network for this innovative solution.
- **Expected impact:** It will enhance the energy efficiency and sustainability by integrating AI driven virtual power plants into Serbia's electricity networks.

Source: 1. AI-driven Virtual Power Plant feasibility

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Serbia's decarbonization efforts face challenges due to heavy reliance on coal, lack of investments and a supportive policy framework

Serbia

Policy	Incentives
There is a need for a more elaborate framework to support the decarbonization efforts of the country	• The Government of Serbia approved the incentives plan for renewables. It has adopted plans to conduct wind and solar power auctions

Infrastructure	Financing
• The country has an outdated infrastructure and is heavily reliant on coal	• Limited access to financing as financial institutions in Serbia are often hesitant to finance renewable energy projects due to perceived risks and lack of familiarity with the sector

Key Policies and Regulations

Law on the use of renewable energy sources	• This law defines the renewable energy framework and introduces auction-based trading in renewables-based energy. It also allows the government to conclude strategic partnerships for renewable-energy projects.
Integrated National Energy and Climate Plan of the Republic of Serbia	• This plan aims to increase the share of renewable energy in the energy mix by promoting the use of solar, wind , biomass and reduce the greenhouse gas emissions in the country, thus decarbonizing the economy.

Key Initiatives and collaborations

Balkan renewable energy program	• Serbia is a part of the Balkan Renewable Energy Program's goal is to "green" economies of member countries, diversify their energy mix and helping them transition to a low carbon future that will result in environmental and social benefits.

Key takeaways

Serbia can move towards decarbonization by implementing stable and supportive policies while increasing investments in renewable energy and green technologies

Source: 1. Decarbonization in Serbia; 2. Balkan Renewable Energy Program

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Serbia are…

Serbia

Key industries	Most relevant technologies
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Metals-Iron & steel	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Industry Agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1- Circular communities in Serbia

- **Name of the technology:** While Serbia does not have technology - based projects, they are promoting circular economy which will help in decarbonization.
- **Project description:** This project is implemented by UNDO Serbia and is funded by the Global Environmental Fund(GEF), aims to reduce the carbon footprint of the local communities by promoting circular economy principles. This project focusses on establishing supportive public policies, training stakeholders, and encouraging community participation.
- **Expected impact**: The project aims to lower the carbon foot- print by advancing circular economy initiatives and supporting sustainable policies and investments.

Source: 1. Circular communities in Serbia

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Financial constraints and technical hurdles challenge smart grid implementation in Jordan

Jordan

Policy	Incentives
• There is a need for a more comprehensive legislative frameworks to accelerate smart meter / smart grid deployment in the country	• The cost of electricity is high in Jordan with a fixed tariff. There is a need for a dynamic tariff that would transform the electricity consumption, leading to reduced demands in peak times and better management.

Infrastructure	Financing
• There is a shortage of human resources to install smart meters in the country	• Lack of capital funds that distribution companies require for setting up smart meters in the country

Key Policies and Regulations

Energy Strategy of Jordan (2020-2030)	• It places a strong emphasis on modernizing its energy infrastructure, particularly through the integration of smart networks, smart meters and energy storage systems.

Key Initiatives and collaborations

Smart meter implementation and engineering support	• Jordan Electric Power Company (JEPCO) is planning to implement a smart metering solution by replacing all the operational conventional electromechanical and digital meters with smart meters as well as deploying the necessary IT systems to manage around 1.5 million smart energy meters.

Key takeaways

With the help of international collaborations and investments in workforce training, Jordan can accelerate its development in the smart energy sector

Source: 1. Smart meters in Jordan; 2. Smart Metering project in Jordan

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Jordan and seeing adoption are…

Jordan

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Study of smart grid options in Jordan

- **Name of the technology** Smart grid networks
- **Project description**: This is a World Bank financed project being carried out by VIS an economic and energy consulting company along with Tetra Tech. The study aims to assist the Government of Jordan in developing a smart grid strategy. It involves technical and economic assessment of smart grid technologies as well as upgradation of the legal and regulatory framework.
- **Expected impact:** It will enhance Jordan's energy infrastructure and improve energy efficiency in the country.

Source: 1. Study of Smart Grid Options in Jordan

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Jordan's decarbonization efforts are hindered by infrastructure gaps, regulatory and financial barriers

Jordan

Policy	Incentives
• The policies promote investment in renewable energy sources and reduced dependence on fossil fuels, however, challenges include the need for R&D, and long-term institutional support	• Jordan has implemented the Net Metering System and the Renewable energy and efficiency fund, but they offer limited scope and insufficient incentives

Infrastructure	Financing
• The electrical grid in Jordan has limited capacity and cannot accommodate diversity in electricity-generation sources	• High upfront costs of installing renewable energy systems at the household level and the lack of financing options are also major barriers to realizing small-scale projects in Jordan

Key Policies and Regulations

Energy Strategy of Jordan (2020-2030)	• It aims to diversify energy sources, enhance energy security and promote sustainable development in the country.
Renewable energy and energy efficiency	• This law aims to meet the national energy targets by facilitating renewable energy projects and proving financial support through the renewable energy and energy efficiency fund.

Key Initiatives and collaborations

Climate Finance in Focus: Jordan's Decarbonization Finance Directory for the Clean Energy Transition	• USAID's Energy Sector Support Activity created the Decarbonization Finance Directory. This resource serves as a comprehensive guide to various financial opportunities that underpin decarbonization projects in Jordan, showcasing the use of diverse climate finance market instruments.
Integrated adoption of electric mobility in Jordan	• This project aims to accelerate the adoption of electric mobility in urban areas of Jordan. Funded by Global Environment Facility (GEF) and implemented by UNIDO and Global Green Growth Institute (GGGI), the project focusses on policy support, capacity building and technological transfer to promote low carbon transport.

Key takeaways

Jordan can progress towards decarbonization by expanding renewable energy infrastructure, enhancing financial incentives and reducing reliance in fossil fuels through strategic policy reforms

Source: 1. Jordan's Decarbonization Finance Directory for the Clean Energy Transition; 2. Integrated adoption for electric mobility in Jordan

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Jordan are…

Jordan

Key industries	Most relevant technologies
Power and Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Industry Agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Anaerobic digestion and biological methanation with hydrogen (biomethane)

Key technologies seeing activity in the country

01

Brief case study -1- Supporting Jordan in developing a modern and eco-friendly waste management system

- **Name of the technology:** While Jordan does not have technology - based projects, they are promoting circular economy which will help in decarbonization.
- **Project description:** This project, supported by Federal Ministry of Economic Cooperation and Development (BMZ) and EU (European Union) aims to modernize Jordan's waste management system. It focusses on updating the National Waste Management Strategy, integrating digital waste monitoring and involving the private sector.
- **Expected impact**: This initiative will create a more efficient, sustainable, and ecofriendly waste management system in Jordan.

Source: 1. Supporting Jordan in developing a modern and eco-friendly waste management system

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Lack of policies and incentives, limited financing and infrastructure challenges are barriers to creating a smart energy ecosystem in Ghana

Ghana

Policy	Incentives
• The policy landscape in Ghana constitutes largely of strategies and plans on renewable energy and energy efficiency without any policies focused on smart energy solutions such as smart grids, smart meters, etc.	• There is lack of incentives to encourage the adoption of smart energy solutions in Ghana

Infrastructure	Financing
• Ghana faces challenges such as an unreliable electricity supply, power outages, transmission and distribution losses, etc. Investments are required to upgrade and modernize its infrastructure	• There is significant need to mobilize finance from public, private and international donors for implementing smart energy projects in the country

Key Policies and Regulations

National Energy Policy	• This policy outlines the energy sector goals, objectives, and issues and their respective policy directions with a focus on power generation, transmission and distribution, renewable energy, energy efficiency and conservation.
National Energy Transition Framework	• This document lays out a framework for decarbonizing the energy sector and reaching net zero emissions by 2070.The framework has been prepared to provide the vision and guidance in the energy transition process with a focus on decarbonization, energy efficiency, energy security and access and cross cutting.
Ghana Energy Transition and Investment Plan	• The plan will help Ghana frame an energy transition agenda that will attract investment while at the same time ensuring a just transition and fully supporting Ghana's rapid economic growth trajectory.

Key Initiatives and collaborations

Smart Energy Solutions for Africa (SESA)	• SESA is a collaborative initiative between the European Union and nine African countries including Ghana that aims at providing energy access technologies such as smart micro grids and BESS. It facilitates the co-development of scalable and replicable energy access innovations, to be tested, validated, and later replicated throughout the African continent.
Project Development Programme (PDP)	• The PDP supports the promotion of sustainable energy solutions in developing and emerging countries including Ghana. It develops financially viable projects focusing on photovoltaic, battery storage, energy efficiency and heat projects, green hydrogen together with local companies.
Green People's Energy for Africa	• It is an initiative by German Federal Ministry for Cooperation and Development which offers citizens of Sub-Saharan Africa including Ghana, innovative technical and financial support for the acquisition of decentralized renewable energy systems. It focuses on rural electrification through off-grid solutions like solar home systems and hybrid mini-grids.

Key takeaways

- Ghana lags in adopting smart energy solutions due to lack of focused policies and incentives as well as infrastructure and financial challenges. Initiatives and collaboration can help create a favourable environment in the country and facilitate the creation of a smart energy ecosystem.

Source: 1. Smart Energy Solutions for Africa 2. Project Development Programme (PDP) 3. National Energy Policy 4. Green People's Energy for Africa

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Ghana and seeing adoption are…

Ghana

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1- Scaling up Renewable Energy Programme (SREP)

- **Name of the technology:** Mini-grids, standalone solar photovoltaic (PV) systems
- **Project description**: SREP investment plan is helping to create an enabling environment for renewable energy scale-ups — focusing on renewable energy mini-grids and standalone solar photovoltaic (PV) systems, solar PV-based net metering with storage, and utility scale solar PV and wind power generation.
- **Expected impact**: SREP will provide electricity access to remote and undeserved areas, reduce emissions and enhance energy security.

Source: 1. Scaling up renewable energy program in low-income countries

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

A developed infrastructure and adequate financing required to adopt industrial decarbonisation solutions in Ghana

Ghana

Policy	Incentives
• The policy landscape of Ghana is focused on renewable energy, energy efficiency and circular economy practices. Regulatory bodies such as the energy commission also exists in the country.	• Under the Energy transition and Investment Plan, incentives will be provided for investments in new clean technologies, renewable energy projects, uptake of low carbon fuels, etc.

Infrastructure	Financing
• As per the National Energy Transition Framework, Ghana will establish public private partnerships (PPP) to co-finance the construction, development and deployment of energy transition infrastructure.	• Ghana faces challenges in financing industrial decarbonization projects. It needs access to public and private finance as well as international support in the form of climate funds, etc.

Key Policies and Regulations

National Energy Policy	• This policy outlines the energy sector goals, objectives, and issues and their respective policy directions with a focus on power generation, transmission and distribution, renewable energy, energy efficiency and conservation, etc..
Circular Economy Action Plan (CEAP)	• The plan outlines clear goals and actions to advance the circular economy in Ghana and includes a governance structure, a costing overview and monitoring and evaluation framework.
Renewable Energy Master Plan (REMP)	• The plan provides investment-focused framework for the promotion and development of renewable energy resources in Ghana.

Key Initiatives and collaborations

Establishing a circular economy framework for the plastics sector in Ghana	• Implemented by UNIDO, the initiative aims to strengthen Ghana's capacity to transition to a circular economy framework and facilitate sustainable plastics management by operationalizing the National Plastic Action Partnership and National Plastic Management Policy.
Go Circular	• Go circular programme is focused on promoting circular economy practices at the global level with a focus on 3 countries- Vietnam, Ghana and Colombia. It operates in 3 areas of actions: promote innovation, scale solutions and work in global alliances.
Decarbonization of industry and climate resilient development in Ghana	• The initiative supports decarbonization and climate proofing of Ghana's industries via 3 components: (1) reducing climate-induced health risks; (2) technical assistance for decarbonizing industrial energy systems and improved energy efficiency and (3) de-risking energy efficiency and renewable energy investments.

Key takeaways

- Ghana has potential to adopt industrial decarbonization solutions with a well-developed infrastructure and adequate financing. Moreover, the initiatives and collaboration in the country will facilitate the uptake of such solutions.

Source: 1. Centre of Excellence for the Circular Economy in Ghana; 2. Go circular 3. Ghana Energy Transition and Investment Plan 4. Ghana's National Energy Transition Framework

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Ghana are…

Ghana

Key industries	Most relevant technologies
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Iron and steel	• Electricity in the Bayer process- Aluminium • Hydrogen based DRI- Iron & Steel • Improved ore refining methods (DRI)
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

01 Brief case study 1- Africa Circular Economy Alliance (ACEA)

- **Technology name:** while Ghana does not have technology-based projects, it is promoting circular economy which will help in decarbonization
- **Initiative description**: ACEA has the following 3 pillars: policy development, leadership and advocacy and scaling circular economy projects and businesses. The Alliance is funded by the African Circular Economy Facility which is a multi-donor trust fund dedicated to promoting the circular economy across Africa.
- **Expected impact**: ACEA will contribute towards knowledge creation and dissemination, stakeholder engagements, capacity building and policy development in the African region.

02 Brief case study 2 - Centre for Excellence for the Circular Economy in Ghana

- **Technology name:** while Ghana does not have technology-based projects, it is promoting circular economy which will help in decarbonization
- **Initiative description:** the initiative by UNIDO will assist Ghana-based organizations and individuals, small scale entrepreneurs, the private sector and informal sector, to develop and deploy innovative circular economy technologies and business models.
- **Expected impact**: improvement in the ability of entrepreneurs (including women), to access resources and technologies that would enable them to identify, design, develop and scale up circular economy business models.

Source: 1. IEA-Ghana emissions; 2. Ghana's Fifth National Greenhouse Gas Inventory ; 3. Africa Circular Economy Alliance; 4. Centre for Excellence for the Circular Economy in Ghana

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Malawi faces policy, financing and infrastructure related challenges in adopting smart energy solutions

Malawi

Policy	Incentives
• Malawi does not have a specific policy for smart energy or smart grids. The policy primarily focuses on building grid-scale and min-grid renewable energy	• There is lack of incentives for encouraging the adoption of smart energy solutions in Malawi

Infrastructure	Financing
• Malawi struggles with low electricity access due to an underdeveloped infrastructure. The challenges include lack of reliable grids, distribution and trans-mission losses, frequent power outages, etc.	• Malawi, being one of the least developed countries in the world, is challenged with low access to finance. • Need for investments in smart grid and off grid technologies

Key Policies and Regulations

Renewable Energy Strategy	The Strategy sets out a detailed set of priorities and actions to achieve the Malawi's vision of universal access to renewable electricity and a sustainable bioenergy sector. It focuses on four priority renewable energy areas: I) grid-scale renewables, (ii) clean energy mini-grids, (iii) off-grid solar, and (iv) bioenergy.
National Electrification Strategy & Action Plan	The Malawi National Electrification Strategy (NES) aims to establish an actionable framework for implementing the National Energy Policy (NEP) priorities. It emphasizes roles and responsibilities for the government, private sector, donors and other stakeholders in Malawi. One of its focus areas is to scale-up mini-grid and standalone solar off-grid system development in the country.

Key Initiatives and collaborations

Smart Energy Solutions for Africa (SESA)	• Smart Energy Solutions for Africa (SESA) is a collaborative initiative between the European Union and nine African countries including Ghana that aims at providing energy access technologies such as smart micro grids and BESS. It facilitates the co-development of scalable and replicable energy access innovations, to be tested, validated, and later replicated throughout the African continent.
Global Energy Alliance for People and Planet (GEPP)	• GEPP initiatives in Malawi include projects focused on deploying battery energy storage systems (BESS) to strengthen grids and enable them to rapidly adopt high levels of leas-cost variable renewable energy.
Africa Mini-grids Programme (AMP)	• Led by UNDP, AMP is a technical assistance program for mini-grids, active in 21 African countries including Nigeria. It targets early-stage mini-grid markets, seeking to establish an enabling environment for subsequent private investment at scale. The objective is to solve the electricity challenges in Africa.

Key takeaways

- Malawi's slow adoption of smart energy solutions can be attributed to an underdeveloped policy landscape, unreliable electricity infrastructure and challenging financial conditions.

Source: 1. Smart Energy Solutions for Africa; 2. Energising Development (EnDev); 3. National Electrification Strategy & Action Plan; 4. Renewable Energy Strategy

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Existing smart energy landscape in Malawi is under-developed; However, has potential to adopt smart grid technologies

Malawi

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid

Key technologies seeing activity in the country

01

Brief case study 1– Energising Development (EnDev)

- **Name of the technology:** mini-grids
- **Project description**: EnDev is an international initiative supporting decentralized, climate-friendly energy solutions which includes solar power systems, village mini-grids and clean cooking technologies. It develops skills, competencies and business models, promotes product innovations and raises public awareness.
- **Expected impact:** achieve a better and reliable energy situation for households, micro, small and medium-sized enterprises and social facilities with a particular focus on poor sections of the population.

02

Brief case study 2– Malawi Electricity Access Project

- **Name of the technology:** mini-grids, solar home systems
- **Project description**: the objective of this project is to support the Government of Malawi to increase access to electricity in the country. It focuses on grid electrification, developing the off-grid market and financing technical assistance and capacity building activities. It emphasizes on the deployment of off-grid technologies such as mini-grids, solar home systems, etc.
- **Expected impact:** the project aims to provide electricity access and improve the quality of life of the Malawi population.

Source: 1. Malawi Electricity Access Project; 2. Energising Development

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Lack of a robust policy landscape, infrastructure and financial position limits industrial decarbonisation in Malawi

Malawi

Policy	Incentives
• Malawi's industrial decarbonization efforts are driven through National Energy Policy which focuses implementation of biomass and biofuels projects	• There is lack of incentives to encourage the adoption of industrial decarbonization solutions in Malawi

Infrastructure	Financing
• Malawi struggles with an underdeveloped infrastructure and technologies which limit the adoption of industrial decarbonization practices and projects	• Malawi, being one of the least developed countries in the world, is challenged with low access to finance for implementing industrial decarbonization practices / projects

Key Policies and Regulations

National Energy Policy	• This policy seeks to guide planning and implementation of programs, projects and activities in the energy sector with the aim of increasing access to reliable, sustainable, efficient and modern energy services. It has identified renewable electricity, biomass and other biofuels as some of the priority areas of action. The government will manufacture and promote the use of renewable energy and modern biomass technologies.

Key Initiatives and collaborations

Sustainable Energy For All (SEforALL) Africa Hub	• It is a partnership hosted by the African Development Bank aimed at facilitating the Sustainable Energy for All initiative in Africa which has 3 objectives to be achieved by 2030- 1) ensure universal access to modern energy services, 2) double the global rate of improvement in energy efficiency and 3) double the share of renewable energy in the global energy mix. 44 African countries have joined the SEforALL Initiative. The Africa Hub supports them through technical assistance, advisory services, policy dialogue and advocacy.
UNEP Chemicals and Waste Management initiative	• Malawi is launching a three-year initiative to develop sound chemicals and waste management practices. The activities will focus on raising public awareness, piloting a plastics recycling project and establishing an integrated information management system for chemicals and waste. It promotes plastics recycling and efficient resource use contributing to reduced industrial emissions and sustainable development.

Key takeaways

- Malawi struggles with an immature policy and regulatory framework, lack of incentives, underdeveloped infrastructure and a challenging financial position. Significant collaborations and initiatives are required to facilitate adoption of industrial decarbonization practices in the country.

Source: 1. World Bank in Malawi; 2. National Energy Policy; 3. Malawi-Chemicals and Pollution Action; 4. SEforALL Africa Hub

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Power & utilities, transport key end industries that are likely to witness decarbonization efforts; Core manufacturing sector underdeveloped

Malawi

Key industries	Most relevant technologies
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

No key projects / initiatives ongoing

- Malawi is an underdeveloped economy with an unfavorable environment characterized by immature policy and regulatory frameworks, lack of incentives, weak infrastructure and poor financial conditions. These factors explain the lack of adoption of industrial decarbonization practices / activities in the country.

Source: 1. The Greenhouse Gas Inventory System in Malawi

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Initiatives in Nigeria are focused on deploying smart energy solutions to improve electricity access

Policy	Incentives
• The policy landscape of Nigeria focuses on energy efficiency, renewable energy, etc. The national energy policy in the country aims to promote smart meters installation in all households.	• Under the Nigeria Electrification Project (NEP), grants are available for the development of private sector solar mini grids in areas not connected to the national electricity grid.

Infrastructure	Financing
• Nigeria suffers from lack of electricity due to inadequate infrastructure. African Development Bank has invested USD 1.44 billion to support development of energy, power, transport, water and sanitation infrastructure	• The country has access to finance through both national and international collaborations / initiatives to support smart energy solutions.

Key Policies and Regulations

National Energy Policy	• The National Energy Policy provides the framework for sustainable energy development in Nigeria with the overall objective of providing clean, affordable, adequate and reliable energy with the active participation of the private sector. The policy includes a medium-term objective of establishing a framework for the adoption and promotion of smart meters installation in all households.
National Renewable Energy and Energy Efficiency Policy	• The policy is a strategic framework designed to promote the use of renewable energy and enhance energy efficiency across the country.

Key Initiatives and collaborations

Global Energy Alliance for People and Planet (GEAPP) in Nigeria	• GEAPP is accelerating the uptake of distributed renewable energy (DRE) solutions to provide fast, clean and cheap power in Nigeria. This includes building demonstration projects, developing pipelines and supporting the ecosystem to deploy mini-grids and other DRE systems .
Smart Energy Solutions for Africa (SESA)	• SESA is a collaborative initiative between the European Union and nine African countries including Nigeria that aims at providing energy access technologies such as smart micro grids and BESS. It facilitates the co-development of scalable and replicable energy access innovations, to be tested, validated, and later replicated throughout the African continent.
Africa Mini-grids Programme (AMP)	• AMP is a technical assistance program for mini-grids, active in 21 African countries including Nigeria. It targets early-stage mini-grid markets, seeking to establish an enabling environment for subsequent private investment at scale.

Key takeaways

- Nigeria has initiatives focused on the development and deployment of smart energy technologies such as micro and mini grids that provide access to reliable and efficient electricity. However, its challenging financial and infrastructure conditions may slow down the development of a smart energy ecosystem.

Source: 1. National Energy Policy; 2. AFDB,; 3. Smart Energy Solutions for Africa; 4. Nigeria Electrification Project

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Nigeria and seeing adoption are…

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study – Nigeria Electrification Project (NEP)

- **Name of the technology:** mini-grids, solar home systems
- **Project description**: NEP is a Government initiative that is private sector driven and seeks to bridge the energy access deficit by providing electricity to households, MSMEs, educational and healthcare facilities in unserved and underserved rural communities through the deployment of mini grid, solar home systems (SHS), captive power plants and productive use appliances to ensure sustainability of these off-grid solutions.
- **Expected impact**: NEP will help bridge Nigeria's electrification gap, promote sustainable development and improve the quality of life in rural communities.

02

Brief case study -2 - Nigeria Distributed Access through Renewable Energy Scale-up (DARES) project

- **Name of the technology:** mini-grids, standalone solar systems
- **Project description**: the objective is to expand and improve electricity access in Nigeria through distributed renewable energy solutions with a focus on deploying mini-grids and standalone solar systems.
- **Expected impact**: the project aims to increase electricity access, improve energy security and promote sustainable development in Nigeria.

Source: 1. Nigeria Electrification Project; 2. Nigeria DARES project

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

A developed infrastructure and strong financial position needed to achieve industrial decarbonisation in Nigeria


Nigeria

Policy	Incentives
• National policies are focused on renewable energy, energy efficiency and circularity. Use of calcined clay and CCUS in cement production is planned from 2030 onwards as per the energy transition plan	• Feed-in tariffs by the Government to accelerate investment in renewable energy. • Government incentives for private-sector providers to install energy-efficient appliances in rural areas

Infrastructure	Financing
• Nigeria's infrastructure is underdeveloped. The African Development Bank has invested USD 1.44 billion to support the development of energy, power, transport, water and sanitation infrastructure in Nigeria	• As per the Energy Transition Plan, Nigeria requires USD 1.9 trillion to achieve its net zero ambitions by 2060. The country needs to mobilise international support through investment opportunities

Key Policies and Regulations

National Energy Policy	• The policy provides the framework for sustainable energy development in Nigeria with the overall objective of providing clean, affordable, adequate and reliable energy with the active private sector participation. One of its objectives is to promote energy efficiency and conservation best practices in the industrial sector. It will also encourage fuel substitution in industries.
National Renewable Energy and Energy Efficiency Policy	• The policy is a strategic framework designed to promote the use of renewable energy and enhance energy efficiency across the country.
National Policy on Solid Waste Management	• The National Policy on Plastic Waste Management is committed to regulate and control the use of plastics in the jurisdiction as well as ensure its sustainable use throughout the life cycle. It aims to phase out single-use plastics by December 2028.

Key Initiatives and collaborations

Global Cleantech Innovation Programme (GCIP)	• Led by UNIDO, GCIP aims to bridge the gap in business and technology development for cleantech ventures by providing direct support to emerging SMEs and strengthening the cleantech innovation and entrepreneurship ecosystem. It supports SMEs working in areas such as energy efficiency, renewable energy, waste beneficiation, transportation, advanced materials and chemicals.
Project Development Programme (PDP)	• The Project Development Programme (PDP) by GIZ supports the promotion of sustainable energy solutions in developing and emerging countries including Nigeria. It develops financially viable projects focusing on photovoltaic, battery storage, energy efficiency and heat projects and green hydrogen together with local companies.
Promoting sustainable plastic value chains through circular economy practices	• Led by UNIDO, the initiative aims to contribute to Nigeria's inclusive and sustainable industrial development through promotion of circular economy principles and practices to be integrated into effective implementation of plastic waste management and strengthening plastic value chains. It also includes demonstration of recycling systems and innovative technologies.

Key takeaways

- Nigeria requires a robust policy environment along with a developed infrastructure and sufficient funding to implement industrial decarbonization practices / projects and ultimately achieved its net-zero ambitions by 2060.

Source: 1. National Energy Policy; 2. GCIP-Nigeria; 3. AFDB; 4. Nigeria Energy Transition Plan

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Nigeria are…

Key industries	Most relevant technologies
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

01

Brief case study 1- Africa Circular Economy Alliance (ACEA)

- **Technology name**: while Nigeria does not have technology-based projects, it is promoting circular economy which will help in decarbonization.
- **Initiative description**: ACEA has the following 3 pillars: policy development, leadership and advocacy and scaling circular economy projects and businesses. The Alliance is funded by the African Circular Economy Facility which is a multi-donor trust fund dedicated to promoting the circular economy across Africa.
- **Expected impact**: ACEA will contribute towards knowledge creation and dissemination, stakeholder engagements, capacity building and policy development in the African region.

02

Brief case study -2- Advancing Hydropower and Circular Economy in Nigeria

- **Technology name**: while Nigeria does not have technology-based projects, it is promoting circular economy which will help in decarbonization.
- **Initiative description**: led by UNIDO, one component of the initiative focuses on enhancing the management of used-off grid energy equipment and plastics through circular economy practices.
- **Expected impact**: This initiative will mitigate pollution and reduce GHG emissions by promoting circular economy practices.

Source: 1. Africa Circular Economy Alliance; 2. Advancing hydropower and circular economy in Nigeria; 3. Nigeria Energy Transition Plan

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Kenya's deployment of mini-grid solutions is underpinned by its robust infrastructure and a strong financial position

Kenya

Policy	Incentives
• Kenya lacks dedicated policies focused on smart energy solutions such as smart grids, smart meters, etc.	• The Green Mini Grid Facility in Kenya provides grants and technical assistance to promote mini-grid development in Kenya

Infrastructure	Financing
• Kenya is actively modernising its grid infrastructure to support SE technologies. Kenya has deployed mini-grids and has made investments in projects integrating renewable energy in national grids	• Kenya's financial position is supportive of implementing smart energy projects. The country also has access to international aid

Key Policies and Regulations

National Energy Policy (NEP)	• The policy document provides a comprehensive description of the current state of the energy sector and contains policy recommendations for various sub-themes such as coal, renewable energy (including geothermal and hydro in particular), electricity, energy efficiency and conservation.
National Energy Efficiency and Conservation Strategy	• It is the roadmap towards achieving energy efficiency goals that will have an overall positive impact on Kenya's economy. The strategy provides a road map in five identified priority sectors – households, buildings, industry and agriculture, transport and power utilities to realize the goal of sustainably transforming Kenya to an industrialized middle-income nation by the year 2030.

Key Initiatives and collaborations

Renewable Energy Integration Program (REI)	• The REI Program helps Kenya solve system-wide barriers preventing the integration of intermittent renewable energy into national grids. It fills a critical gap in the energy transition by funding power grid modernisation, storage technologies, and other infrastructure and policy updates that can deliver clean power where and when it is needed. It focuses on large-scale deployment of solar and wind power.
Smart Energy Solutions for Africa (SESA)	• SESA is a collaborative initiative between the European Union and 9 African countries including Kenya that aims at providing energy access technologies such as smart micro grids and BESS. It facilitates the co-development of scalable and replicable energy access innovations, to be tested, validated, and later replicated throughout the African continent.
Energizing Development (EnDev)	• An international initiative that supports decentralised, climate-friendly energy solutions such as solar power systems, village mini-grids and clean cooking technologies in over 20 countries including Kenya. It develops entrepreneurial skills, business models and promotes product innovations.

Key takeaways

- Kenya has been able to deploy off grid solutions such as mini-grids owing to a robust infrastructure, incentives and a supportive financial position.

Source: 1. National Energy Policy; 2. Smart Energy Solutions for Africa; 3. Renewable Energy Integration Programme

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Kenya and seeing adoption are…


Kenya

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study 1 – Kenya Off-grid Solar Access Project for Undeserved Counties

- **Name of the technology:** mini-grids and standalone solar power systems
- **Project description**: a flagship initiative by the Government of Kenya aimed at increasing access to modern energy services in underserved counties by deploying mini-grids and stand-alone solar home systems. It will provide implementation support and build capacity.
- **Expected impact**: improved energy access to communities facing energy poverty.

Source: 1. Kenya Off-grid Solar Access Project for Undeserved Counties

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Potential for industrial decarbonisation in Kenya through strengthened policies, robust infrastructure and capacity building


Kenya

Policy	Incentives
• Policy landscape focuses on energy efficiency, renewable energy, circularity, green hydrogen etc. • Kenya suffers from weak policy implementation and an unregulated informal industrial sector	• Feed-in-tariffs implemented to promote renewable energy development • Import duties and VAT have been waived on solar photovoltaic products

Infrastructure	Financing
• Kenya has inadequate infrastructure and access to land to set up pilot plants for industrial decarbonization projects • Limited skilled workers and R&D development activities	• The Finance Act does not focus on climate action but includes measures like tax incentives for renewable energy projects, carbon pricing mechanisms, funding allocations for climate resilience programs

Key Policies and Regulations

National Energy Policy (NEP)	• The policy document provides a comprehensive description of the current state of the energy sector and contains policy recommendations for various sub-themes such as coal, renewable energy (including geothermal and hydro in particular), electricity, energy efficiency and conservation.
Bio-energy strategy	• The strategy aims to : 1) promote the sustainable production, distribution and utilization of bioenergy as a clean source of energy, 2) address the strengths, gaps, opportunities and foreseen challenges to enhance sustainable exploitation of bioenergy.
National Sustainable Waste Management Policy	• The policy aims at addressing waste management through regulations, guidelines and strategies in the country. It will advance Kenya towards a more sustainable and circular economy and will help ensure that waste is collected, separated at the source, reused and recycled, and that the remaining waste stream is destined to a secure, sanitary landfill.

Key Initiatives and collaborations

US-Kenya Climate and Clean Energy Industrial Partnership	• Through this partnership, the United States and Kenya plan to prioritize cooperation across the three mutually-supportive areas of clean energy deployment, clean energy supply chains, and green industrialization. The focus areas will be electric vehicle supply chains and e-mobility, carbon capture and storage technologies, green agricultural processing, clean cooking technologies, and green data centres.
Project Development Programme (PDP)	• The programme by GIZ supports the promotion of sustainable energy solutions in developing and emerging countries including Nigeria. It develops financially viable projects focusing on photovoltaic, battery storage, energy efficiency and heat projects and green hydrogen together with local companies.
CCS partnership between RepAir and Cella	• This partnership is focused on creating dedicated value chains for extracting CO2 from the atmosphere and permanently storing it underground. The direct air capture unit and CO2 storage facility will be located in the Kenyan Rift Valley.

Key takeaways

- Kenya should focus on strengthening policies and regulations along with improving the infrastructure and enhancing the capacity of industry players through training and awareness programs to support decarbonization efforts

Source: 1. Preliminary Roadmap for Industrial decarbonization-Kenya; 2. Project Development Programme; 3. National Energy Policy

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Kenya are…


Kenya

Key industries	Most relevant technologies
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Cement and concrete	• CCUS- Chemical absorption of CO2 using Kilns • Electrification of kilns • Partial use of H2 in kilns
Iron and steel	• Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Chemicals and plastics	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)

Key technologies seeing activity in the country

01

Brief case study -1 - Climeworks and Great Carbon Valley (GCV) collaboration

- **Technology name**: CCUS technologies (Direct air capture and storage)
- **Initiative description**: The collaboration between GCV and Climeworks is focuses on the development of direct air capture and storage (DAC+S) projects in Kenya with a pathway of removing up to one million tons of CO_2 from the atmosphere once fully deployed.
- **Expected impact**: CCUS projects will help reduce emissions and facilitate decarbonization.

02

Brief case study -2- Promoting climate neutral fuels and chemicals

- **Technology name**: Power to X (PtX) technologies
- **Initiative description**: The initiative by GIZ aims to develop sustainable hydrogen and Power to X value chains locally enabling sectors like aviation, shipping and chemicals to transition away from fossil fuels. The concept involves using renewable electricity to produce hydrogen as an energy carrier. Industry then uses the hydrogen directly or processes it into carbon-neutral raw materials or fuels for heating or combustion.
- **Expected impact**: PtX solutions can help in extending the use of renewable energy to sectors that are not directly connected to the electricity grid such as transportation, heating, and cooling. The coupling of these sectors with renewable power can accelerate their decarbonization.

Source: 1. Climeworks; 2. Promoting climate neutral fuels and chemicals; 3. Industrial Decarbonization Accelerator

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Rwanda's favourable policy environment, infrastructure and financial conditions support the adoption of smart energy solutions to solve electricity challenges

Rwanda

Policy	Incentives
• Rwanda's policy landscape favours the adoption of smart energy solutions with a focus on AI, energy efficiency, mini-grids, standalone solar home systems, demand side management, etc.	• Insufficient incentives present for the adoption of smart energy solutions in the country

Infrastructure	Financing
• Infrastructure in Rwanda supports diversification of electricity sources from the traditional grid to include off-grid connections. Remote areas that are of the grid are encouraged to use mini-grids and solar PVs	• Rwanda's financial position is supported by international aid and government commitments. Rwanda's Green Fund supports sustainable development projects

Key Policies and Regulations

The National Artificial Intelligence Policy	• The policy serves as a roadmap to enable Rwanda to harness the benefits of AI and mitigate its risks. Its vision is to become a global center for AI research and innovation and aims to power economic growth, improve quality of life and position Rwanda as a global innovator for responsible and inclusive AI.
Rwanda Energy Policy	• The overall goal of the policy is to ensure that all residents and industries can access energy products and services that are sufficient, reliable, affordable, and sustainable. The policy focuses on the following areas: electricity, petroleum, biomass and energy efficiency and demand side management.
Electricity Access Development Plan	• The plan aims to achieve universal access to electricity by 2024 with a focus on grid expansion, promoting off grid solutions such as mini-grids and standalone solar home systems to serve remote areas.

Key Initiatives and collaborations

Smart Energy Solutions for Africa (SESA)	• SESA is a collaborative initiative between the European Union and nine African countries including Rwanda that aims at providing energy access technologies such as smart micro grids and BESS. It facilitates the co-development of scalable and replicable energy access innovations, to be tested, validated, and later replicated throughout the African continent.
Energising Development (EnDev)	• An international initiative that supports decentralized, climate-friendly energy solutions such as solar power systems, village mini-grids and clean cooking technologies in over 20 countries including Rwanda. It develops entrepreneurial skills, business models and promotes product innovations.
Scaling- Up Renewable Energy in Low Income countries (SREP)	• SREP supports private-sector off-grid energy solutions, such as standalone solar photovoltaic solutions and mini-grids using renewable energy sources to expand energy access in rural areas. SREP financing will help overcome financial, institutional, and technical barriers to establishing sustainable off-grid markets.

Key takeaways

- Rwanda's favourable policy landscape along with a supportive infrastructure and financial position facilitates the adoption of smart energy solutions. Adoption of off-grid technologies such as mini-grids helps solve the electricity challenges experienced by the remote areas in the country.

Source: 1. Rwanda Energy Group; 2. The National AI policy; 3. Rwanda Energy Policy; 4. Rwanda Green Fund

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Rwanda and seeing adoption are…

Rwanda

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1- Accelerating Sustainable and Clean Energy Access Transformation (ASCENT)

- **Name of the technology:** mini-grids, IOT
- **Project description**: ASCENT is aimed at increasing access to sustainable and clean energy in Eastern and Southern Africa including Rwanda. It has the following components: 1) digital monitoring, reporting and verification platforms, 2) energy infrastructure development, 3) decentralized renewable energy solutions such as mini-grids, 4) policy and regulatory support and 5) capacity building.
- **Expected impact**: The initiative will provide access to electricity to 100 million people and access to clean cooking to 20 millionn people across more than 20 countries in Eastern and Southern Africa.

Source: 1. Accelerating Sustainable and Clean Energy Access Transformation in Eastern & Southern Africa

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Presence of an enabling environment for achieving industrial decarbonisation in Rwanda

Rwanda

Policy	Incentives
• Rwanda's policies and strategies encourage the adoption of industrial decarbonization practices with a focus on biomass, renewable energy, energy efficiency and circularity	• Insufficient incentives present for the adoption of industrial decarbonization solutions in the country

Infrastructure	Financing
• Rwanda's infrastructure is supportive of industrial decarbonization. There is still need for investments in modernising infrastructure and enhancing technical capacity	• Rwanda's financial position is supported by international aid and government commitments. Rwanda's Green Fund supports sustainable development projects

Key Policies and Regulations

Rwanda Energy Policy	• The overall goal of the policy is to ensure that all residents and industries can access energy products and services that are sufficient, reliable, affordable, and sustainable. The policy focuses on the following areas: electricity, petroleum, biomass and energy efficiency and demand side management.
Biomass Energy Strategy	• The goal of the strategy is to ensure a more sustainable supply of biomass energy and to promote access to modern fuels as well as to efficient biomass combustion technologies for households and small enterprises. It analyses supply and demand of biomass and sets out a strategy to reduce reliance on wood and charcoal.
Rwanda National Circular Economy Action Plan and Roadmap	• The plan formulates concrete and clear directions for the transition towards a circular economy in Rwanda and lays out clear policy options and underlying activities to advance the circular economy in the waste, water, agriculture and construction sectors in the next years until 2035.

Key Initiatives and collaborations

Africa Circular Economy Alliance (ACEA)	• ACEA is a government-led coalition of African countries, with a mission to drive Africa's transformation to a circular economy that delivers economic growth, jobs, and positive environmental outcomes. The ACEA's main intervention pillars include policy advisory, leadership & advocacy, as well as projects and business scale-up.
Sustainable Energy for All (SEForALL) Africa Hub	• A partnership hosted by the African Development Bank facilitates the SEforALL initiative in Africa which has 3 objectives to be achieved by 2030- 1) ensure universal access to modern energy services, 2) double the global rate of improvement in energy efficiency and 3) double the share of renewable energy in the global energy mix. The Africa Hub supports 44 African countries them through technical assistance, advisory services, policy dialogue and advocacy.
Promoting a sustainable waste and circular economy	• The project by GIZ advises the Rwandan Ministry of the Environment on implementing circular economy approaches in the waste sector together with the private sector. Objectives in this area also include establishing a regular dialogue format with the business community and supporting instruments to implement policies, strategies and plans.

Key takeaways

- Rwanda has a favourable policy environment, infrastructure and financial position along with the presence of initiatives led by international organizations. All these factors provide an enabling environment for achieving industrial decarbonization and net zero ambitions in the country.

Source: 1. Rwanda Energy Policy; 2. National Circular Economy Action Plan and Roadmap; 3. Africa Circular Economy Alliance; 4. Rwanda Green Fund

Key Industries which will enable technology adoption in Rwanda are…

Rwanda

Key industries	Contribution to GDP	Most relevant technologies
Transport		• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Power and utilities		• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Industry agnostic		• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

01

Brief case study -1 - Project Development Programme (PDP)

- **Name of the technology:** energy efficiency, green hydrogen technologies
- **Initiative description**: the programme by GIZ supports the promotion of sustainable energy solutions in developing and emerging countries including Nigeria. It develops financially viable projects focusing on photovoltaic, battery storage, energy efficiency and heat projects and green hydrogen together with local companies.
- **Expected impact**: it helps in market development and capacity building. It will facilitate technology transfer and contribute to economic growth and climate change mitigation.

Source: 1. Project Development Programme; 2. IMF- Rwanda; 3. IEA- Rwanda emissions

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Ineffective policy and regulatory environment discourages the adoption of smart energy solutions in Senegal


Senegal

Policy	Incentives
• Senegal does not have any policies or plans to adopt smart energy solutions	• There is lack of incentives to encourage the adoption of smart energy solutions in the country

Infrastructure	Financing
• Senegal's infrastructure is well equipped to support its electrification objectives. The country is committed to expanding and modernizing its grid infrastructure to improve reliability and efficiency	• Senegal has been able to secure international financial support through the Just Energy Transition Partnership (JETP).

Key Policies and Regulations

Plan for Emerging Senegal	• The Plan for an Emerging Senegal (PSE) aims to transform Senegal into an emerging market economy by 2035. Through inclusive growth, human development, and good governance, leveraging sustainable and climate-resilient initiatives. Its climate related objectives are: 1) promote green investments, 2) enhance climate resilience, 3) sustainable resource management.

Key Initiatives and collaborations

Energising Development (EnDev)	• An international initiative that supports decentralized, climate-friendly energy solutions such as solar power systems, village mini-grids and clean cooking technologies in over 20 countries including Senegal. It develops entrepreneurial skills; business models and promotes product innovations.
Promoting renewable energies in Senegal	• The project by GIZ aims to increase the share of renewable energy in its electricity mix, promote off-grid solutions and fairer tariffs, launch pilot projects and ensure fair, affordable, and universal energy access. It will support energy access through the expansion of grid-connected renewable energies.

Key takeaways

- Lack of a smart energy ecosystem in Senegal owing to inadequacy of focused policies and regulations related to smart energy solutions.

Source: 1. Rwanda Energy Group; 2. Promoting renewable energies in Senegal; 3. Just Energy Transition Partnership

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Senegal and seeing adoption are…

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 – Green People's Energy for Africa

- **Name of the technology:** mini-grids, off-grid solar systems
- **Initiative description**: Green People's Energy for Africa (GBE) is an initiative created by the German Federal Ministry for Cooperation and Development which offers citizens of Sub-Saharan Africa including Senegal, innovative technical and financial support for the acquisition of decentralized renewable energy systems, and in particular photovoltaic systems. It focuses on rural electrification through off-grid solutions like solar home systems and hybrid mini-grids.
- **Expected impact**: the initiative aims to support the supply of electricity for productive use, as well as for social institutions in rural areas, through the involvement of local actors and private investors, in order to improve livelihoods and household incomes.

Source: 1. Green People's Energy for Africa

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Senegal struggles with an underdeveloped policy landscape, weak infrastructure and financial conditions limiting industrial decarbonisation practices


Senegal

Policy	Incentives
• Policy landscape in Senegal is immature. The country has not adopted a net-zero target yet and does not have focused policies / regulations supporting industrial decarbonization	• VAT exemption of renewable energy materials and products including solar panels, inverters, etc. The tax exemption aims to support the country's electrification efforts

Infrastructure	Financing
• The country has an outdated infrastructure not equipped to support industrial decarbonization projects. Despite having abundant renewable energy potential, there's dependence on imported fossil fuels	• Senegal faces critical financial challenges. There is a significant need of international support and other financial mechanisms to accelerate investments in industrial decarbonisation

Key Policies and Regulations

Plan for Emerging Senegal	• The Plan for an Emerging Senegal (PSE) aims to transform Senegal into an emerging market economy by 2035. Through inclusive growth, human development, and good governance, leveraging sustainable and climate-resilient initiatives. Its climate related objectives are: 1) promote green investments, 2) enhance climate resilience, 3) sustainable resource management.
Plastic law 2020	• Senegal's 2020 law addresses prevention and reduction of impacts on the environment and human health of plastic products and the ecological management of plastic waste.

Key Initiatives and collaborations

Africa Circular Economy Alliance (ACEA)	• ACEA is a government-led coalition of African countries, with a mission to drive Africa's transformation to a circular economy that delivers economic growth, jobs, and positive environmental outcomes. The ACEA's main intervention pillars include policy advisory, leadership & advocacy, as well as projects and business scale-up.
Project Development Programme (PDP)	• The programme by GIZ supports the promotion of sustainable energy solutions in developing and emerging countries including Senegal. It develops financially viable projects focusing on photovoltaic, battery storage, energy efficiency and heat projects and green hydrogen together with local companies
Sustainable Energy for All (SEforALL) Africa Hub	• A partnership hosted by the African Development Bank facilitates the SEforALL initiative in Africa which has 3 objectives to be achieved by 2030- 1) ensure universal access to modern energy services, 2) double the global rate of improvement in energy efficiency and 3) double the share of renewable energy in the global energy mix. The Africa Hub supports 44 African countries them through technical assistance, advisory services, policy dialogue and advocacy.

Key takeaways

- Senegal has an underdeveloped policy and regulatory framework and has not adopted a net-zero target yet. Moreover, a weak infrastructure and challenging financial situation creates an unfavourable environment for the adoption of industrial decarbonisation in the country.

Source: 1. Emerging Senegal Plan; 2. Africa Circular Economy Alliance; 3. SEforALL Africa Hub

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Senegal are…


Senegal

Key industries	Most relevant technologies
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Chemicals and plastics	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

01

Brief case study -1 - SUNU Plastic Odyssey project

- **Name of the technology:** while Senegal does not have technology-based projects, it is promoting circular economy which will help in decarbonization.
- **Initiative description**: the SUNU project, implemented by Plastic Odyssey with the support of the French Embassy in Senegal, the Senegalese authorities and its partners, aims to support the development of an industrial sector for the recycling and recovery of plastic waste.
- **Expected impact**: this collaborative project, supported by numerous partners, aims to transform the country's waste into resources, create jobs, raise awareness and promote circular economy practices in the industrial sector contributing to its decarbonization.

02

Brief case study -2 – Global Cleantech Innovation Programme

- **Name of the technology:** clean energy technologies across sectors
- **Initiative description**: led by UNIDO, GCIP aims to bridge the gap in business and technology development for cleantech ventures by providing direct support to emerging SMEs and strengthening the clean-teach innovation and entrepreneurship ecosystem. It supports SMEs working in areas such as energy efficiency, renewable energy, waste beneficiation, transportation, advanced materials and chemicals.
- **Expected impact**: development of a clean-tech innovation and entrepreneurship ecosystem in the country to achieve decarbonization and sustainable development.

Source: 1. SUNU Plastic Odyssey project; 2. GCIP- Senegal; 3. IEA-Senegal emissions

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

An immature policy landscape, lack of incentives and poor infrastructure and financial conditions limit the adoption of smart energy solutions in the Gambia

The Gambia

Policy	Incentives
• The Gambia lacks dedicated policies and regulations focused on smart energy solutions. The existing policy landscape promotes digital economy, grid modernization and energy efficiency practices	• Lack of incentives to encourage the adoption of smart energy solutions in the country
Infrastructure	**Financing**
• Inadequate electricity infrastructure with transmission and distribution losses, poor reliability of electricity from the grid are some of the challenges faced by the Gambia	• The Gambia struggles with limited financing for investments in smart energy projects

Key Policies and Regulations

National Digital Economy Master Plan	• The Gambia Digital Economy Master Plan 2033 consists of 10 pillars that guide the development of The Gambia to a fully digital state powered by resilient digital infrastructure and cutting-edge digital technologies with flourishing information technology innovation and entrepreneurship.
National Energy Efficiency Strategy	• The strategy consists of a set of actions for The Gambia to take based on its current electricity consumption patterns and opportunities for improving energy efficiency. The strategy includes targets and measures across the following sectors: residential, productive, cooking and public services.
Electricity Sub-sector Roadmap 2021-2040	• The roadmap outlines medium and long-term investments needed in generation, transmission and distribution infrastructure to meet national electricity demand. It emphasizes on the deployment of solar off-grid systems, mini-grids, etc. as well as the modernization of the electricity sector.

Key Initiatives and collaborations

Renewable Energy Framework	• Supported by the European Investment Bank (EIB), it is an initiative aimed to transforming the country's energy sector. It focuses on 1) on and off-grid renewable energy generation, 2) investments to modernise and expand the transmission and distribution networks, 3) deployment of off-grid PV and BESS technologies in rural health clinics, schools, etc.

Key takeaways

- The Gambia lacks effective policies and incentives and faces challenging infrastructure and financial conditions limiting the adoption of smart energy solutions in the country.

Source: 1. National Digital Economy Master Plan; 2. National Energy Efficiency Strategy; 3. Electricity Sub-sector Roadmap; 4. Renewable Energy Framework

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Smart energy ecosystem is underdeveloped in the Gambia

The Gambia

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

No key projects / initiatives ongoing

- Gambia does not have an enabling environment to introduce or adopt smart energy solutions which can be attributed to an underdeveloped policy landscape, poor financial position and a weak infrastructure. Moreover, Gambia primarily depends on its agricultural sector leaving limited scope for the adoption of smart energy solutions in the economy.

Source: 1. IFAD-Gambia; 2. Gambia Agricultural Sector

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Limited industrialisation along with a poor enabling environment in the Gambia reduces potential for decarbonisation activities

The Gambia

Policy	Incentives
• The Gambia's policy and regulatory landscape is not mature to support industrial decarbonization. It mainly comprises of climate related strategies and plans	• Lack of incentives in the country for supporting industrial decarbonization practices

Infrastructure	Financing
• The Gambia is challenged with poor infrastructure which is not equipped to support decarbonization technologies and projects	• The multinational and biliteral donors are active in supporting the country's climate ambitions. However, being a low-income developing country, its finance needs are higher than the aid received

Key Policies and Regulations

National Energy Efficiency Strategy	• The strategy consists of a set of actions for The Gambia to take based on its current electricity consumption patterns and opportunities for improving energy efficiency. The strategy includes targets and measures across the following sectors: residential, productive (industries), cooking and public services.
Long Term Climate-Neutral Development Strategy 2050 (LTS)	• The strategy focuses on the country`s 5 key GHG emitting sectors - namely Energy; Agriculture; Waste Management; Transport and Land Use Land Use Change and Forestry. The LTS looks at both mitigation and adaptation actions that would require funding, for the country to reach net-zero emissions by 2050.
National Climate Change Policy	• The goal of the policy is, by 2025, to achieve the mainstreaming of climate change into national planning, budgeting, decision-making, and programme implementation, through effective institutional mechanisms, coordinated financial resources, and enhanced human resources capacity.

Key Initiatives and collaborations

Plastic recycling initiative by Waste Aid	• The initiative will involve the training of collector groups, setting up collection infrastructure, behavior change campaigns as well as business training support to Plastics Recycling Gambia, a recycling company to help expand its business. Waste Aid's initiative aims to increase the volume of plastic recycled at the plant to 50 tones each month. It will also create jobs in the waste sector and educate the community. The initiative promotes material efficiency and circular economy practices.
Sustainable Energy for All (SEforALL) Africa Hub	• It is a partnership hosted by the African Development Bank aimed at facilitating the Sustainable Energy for All initiative in Africa which has 3 objectives to be achieved by 2030- 1) ensure universal access to modern energy services, 2) double the global rate of improvement in energy efficiency and 3) double the share of renewable energy in the global energy mix. 44 African countries have joined the SEforALL Initiative. The Africa Hub supports them through technical assistance, advisory services, policy dialogue and advocacy.

Key takeaways

- The Gambia struggles with an immature policy landscape, poor infrastructure and challenging financial conditions. The country has limited industrial activities due to its dependence on the agricultural sector which explains lack of initiatives and collaborations on industrial decarbonization.

Source: 1. Climate Change Vulnerabilities and Strategies: The Gambia; 2. National Energy Efficiency Strategy; 3. National Climate Change Policy; 4. SEforALL Africa Hub

The Gambia is an agrarian economy with a limited industrial base

The Gambia

Key industries

- **Power and utilities**
- **Transport**
- **Industry agnostic**

Most relevant technologies

- **Power and utilities**
  - Post-combustion: chemical absorption (biomass with CCUS)
  - Co-firing of ammonia in coal power plants
  - Linear Fresnel reflector (solar)
- **Transport**
  - High temp based PEMFC
  - Ammonia-fuelled ship engine
  - Hydrogen-fuelled urban transit bus and trucks
- **Industry agnostic**
  - Biorefining
  - Biomass gasification and catalytic methanation (biomethane)
  - Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

01

Brief case study -1 -Renewable Energy Potentials in the Gambia (REPGam) project

- **Name of the technology:** renewable energy technologies
- **Initiative description**: funded by the German Federal Ministry of Education and Research (BMBF), the REPGam research project aims to advance knowledge and technology transfer in The Gambia and to foster the expansion of renewable energy, considering aspects related to the economy, ecology, and society.
- **Expected impact**: The initiative will strengthen the employment prospects of the population in the field of renewable energy technologies as well as enhance the quality of life by providing clean and affordable electricity.

Source: 1. REPGam; 2. IFAD-Gambia; 3. The Gambia Agricultural Sector; 4. IMF- The Gambia

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Enabling environment present for the development and deployment of mini-grids in Tanzania


Tanzania

Policy	Incentives
• Tanzania's policy landscape supports the adoption of off-grid technologies such as mini-grids to increase rural electricity access	• Incentives for rural electrification projects - grants for feasibility studies, deployment of mini-grids, construction loans, etc. Mini-grids (< 1 MW capacity) exempted from procuring a license to operate

Infrastructure	Financing
• The number and installed capacity of mini-grids has nearly doubled since the Government introduced small power producer's framework policy indicating a supportive infrastructure for off-grid technologies	• Insufficient public and private sector funding for implementing smart energy solutions in the country

Key Policies and Regulations

Energy Efficiency Action Plan	• The overarching aim is to enhance energy efficiency across various sectors to reduce energy consumption and improve overall energy performance. This is achieved through implementing policies, standards, and initiatives that promote the adoption of energy-efficient technologies and practices, alongside awareness campaigns and capacity-building effort.
Small Power Producers Framework Policy	• This framework has been instrumental in promoting the development of mini-grids and small-scale power generation projects. It encourages the development of off-grid solutions to increase electricity access in underserved areas.
National Energy Policy (NEP)	• The policy aims to provide sustainable, reliable and affordable energy. It focuses on (i) electricity generation and rural electrification; (ii) petroleum and gas upstream, midstream, and downstream activities; (iii) renewable energy, energy conservation, and energy efficiency and (iv) cross-cutting issues.

Key Initiatives and collaborations

Energizing Development (EnDev)	• An international initiative that supports decentralised, climate-friendly energy solutions such as solar power systems, village mini-grids and clean cooking technologies in over 20 countries including Tanzania. It develops entrepreneurial skills, business models and promotes product innovations.
Smart Energy Solutions for Africa (SESA)	• SESA is a collaborative initiative between the European Union and nine African countries including Rwanda that aims at providing energy access technologies such as smart micro grids and BESS. It facilitates the co-development of scalable and replicable energy access innovations, to be tested, validated, and later replicated throughout the African continent.
USAID-NREL Partnership	• The USAID and NREL Partnership is supporting Tanzania with integrating renewable energy into the grid through power system modeling and development of high-quality resource data. Key focus areas are: utility scale renewable energy generation and energy storage technology.

Key takeaways

- Tanzania has a supportive policy framework and infrastructure to deploy off-grid smart energy technologies such as mini-grids for rural electrification.

Source: 1. Energy Efficiency Action Plan; 2. National Energy Policy; 3. USAID-NREL Partnership-Tanzania

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Key smart energy technologies most relevant for Tanzania and seeing adoption are…


Tanzania

Relevant technology types	Most relevant technologies
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • Demand response to information • Industrial demand response for frequency balancing and voltage control
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra fast charging • Inductive charging
Digital technologies and automation	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study 1 – iGrid Project

- **Name of the technology:** smart microgrid
- **Project description**: The goal of the project is to design and implement autonomous solar-powered DC smart microgrid that can satisfy the energy demands of small local rural communities. Funded by the Sweden Government, this project is a collaboration between two Universities: The Royal Institute of Technology (KTH) in Sweden, and the University of Dar es Salaam (UDSM) in Tanzania
- **Expected impact**: Improve electricity access in off-grid communities especially rural areas

02

Brief case study -2 - Accelerating Sustainable and Clean Energy Access Transformation (ASCENT)

- **Name of the technology:** mini-grids, IOT
- **Project description**: ASCENT is aimed at increasing access to sustainable and clean energy in Eastern and Southern Africa including Tanzania. It has the following components: 1) digital monitoring, reporting and verification platforms, 2) energy infrastructure development, 3) decentralised renewable energy solutions such as mini-grids, 4) policy and regulatory support and 5) capacity building
- **Expected impact**: the initiative will provide access to electricity to 100 million people and access to clean cooking to 20 million people across more than 20 countries in Eastern and Southern Africa

Source: 1. iGrid project; 2. Accelerating Sustainable and Clean Energy Access Transformation

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Limited presence of industrial sector and activities in Tanzania reduces scope for decarbonisation solutions


Tanzania

Policy	Incentives
• Tanzania's policy and regulatory landscape is under-developed and there is a need for effective policies to support industrial decarbonization activities in the country	• Lack of incentives to encourage industrial decarbonization in the country

Infrastructure	Financing
• Tanzania's infrastructure has seen improvements. The country has made investments in energy and transport infrastructure which is conducive for industrial decarbonization activities	• Tanzania has attracted investments in carbon offset credits. This market is crucial for funding climate activities. It also receives financial assistance from international organizations

Key Policies and Regulations

Energy Efficiency Action Plan	• The overarching aim is to enhance energy efficiency across various sectors to reduce energy consumption and improve overall energy performance. This is achieved through implementing policies, standards, and initiatives that promote the adoption of energy-efficient technologies and practices, alongside awareness campaigns and capacity-building effort.
National Solid Waste Management Strategy	• The strategy is aiming at attaining sustainable management of solid waste that contributes to achieving economic and social benefits to Tanzanian people. It has been developed to enable the country meet the goals for solid waste management.
National Energy Policy (NEP)	• The policy aims to provide sustainable, reliable and affordable energy. It focuses on (i) electricity generation and rural electrification; (ii) petroleum and gas upstream, midstream, and downstream activities; (iii) renewable energy, energy conservation, and energy efficiency and (iv) cross-cutting issues.

Key Initiatives and collaborations

Triangular Development Partnership	• The United States, India, and Tanzania have launched a Triangular Development Partnership to strengthen energy infrastructure and promote renewable energy development in Tanzania.
Sustainable Energy for All (SEforALL) Initiative	• It is multi-stakeholder partnership between the Governments, private sector and civil society which has 3 objectives to be achieved by 2030- 1) ensure universal access to modern energy services, 2) double the global rate of improvement in energy efficiency and 3) double the share of renewable energy in the global energy mix.
Scaling Up Renewable Energy Program in Low Income Countries (SREP)	• SREP in Tanzania aims to transform the country's energy sector by increasing the share of renewable energy sources. It focuses on large-scale deployment of renewable energy and reduce reliance on fossil fuels.

Key takeaways

- Tanzania is dependent on the agriculture sector and has a limited industrial base. Moreover, it does not have a favourable policy and regulatory environment to encourage industrial decarbonization practices.

Source: 1 Energy Efficiency Action Plan; 2. National Energy Policy; 3. Triangular Development Partnership

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Tanzania majorly depends on the agriculture sector, with limited industrial base


Tanzania

Key industries	Most relevant technologies
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Power and utilities	• Post-combustion: chemical absorption (biomass with CCUS) • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Industry agnostic	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation.

Key technologies seeing activity in the country

No key projects / initiatives ongoing

- Tanzania majorly depends on its agricultural sector and has a limited industrial base. As a result, the country has not seen industrial decarbonization activities / projects being implemented.

Source: 1. Tanzania- manufacturing; 2. IEA- Tanzania; 3. UNIDO- country statistics

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Indonesia's policy and infrastructure climate is well placed to support investments across smart energy technologies and projects…

Indonesia

Policy	Incentives
• The country has well laid down policies regarding key smart energy elements such as smart grid, EV, Energy efficiency, etc.	• There are numerous incentives that adopters of smart energy technologies in Indonesia can avail – ranging from tax breaks / subsidies to affordable financing (low interest rates)

Infrastructure	Financing
• Indonesia has a wide range of smart energy projects – particularly around smart grid as it is an island nation	• While there is a lack of direct government funding – other funds make up for the lack of the same (Example – Green Climate Fund)

Key Policies and Regulations

Smart Grid Roadmap (RUPTL 2021 – 2030)	• This initiative, led by PT PLN (Persero), aims to revolutionize Indonesia's electricity distribution by integrating smart grid technology and renewable energy sources over the next decade. The focus is on enhancing efficiency and reliability in the power grid.
Regulation No. 79 / 2014 - National Energy Policy	• The National Energy Policy of Indonesia (Government Regulation No. 79 / 2014) aims to achieve energy independence and security by 2050. It focuses on increasing the share of renewable energy to 23% by 2025 and 31% by 2050, enhancing energy efficiency, and developing smart grids and electric vehicle (EV) infrastructure.
Regulation No. 22 / 2017 - National Energy Policy	• The President Regulation No. 55 / 2019 lays down Indonesia's EV regulations focus on accelerating the adoption of battery electric vehicles (BEVs) through incentives, local manufacturing requirements, and the development of charging infrastructure.

Key Initiatives and collaborations

KEPCO, Siemens and PT PLN Collaboration	• KEPCO signed an MoU with Indonesia's PT Perusahaan Listrik Negara (Persero) and Siemens for joint promotion of new technologies and businesses. This includes a high voltage direct current project to connect Java and Sumatra Islands in Indonesia.
Net Zero World Initiative	• Led by the US DOE, The Net Zero World Initiative brings capabilities to help Indonesia's national and city governments accelerate the transition to low-carbon, sustainable mobility. Their goals are to build government capacity and enable policy reform in addition to boost access to decarbonization finance.
Smart Meter Retrofitting	• The project is led by Sindcon, a smart meter provider, in collaboration with ST Microelectronics involves retrofitting over 50,000 smart meters with LoRaWAN wireless microcontrollers, enabling remote meter reading for electricity, gas, and water meters.

Key takeaways

- Indonesia's smart energy ecosystem is built on strong policies and infrastructure, promoting investments in renewable energy technologies. The framework includes strategic planning, financial support, and international collaborations to enhance the country's energy efficiency and sustainability.

Source: 1. Ashurst; 2. Asia Pacific Energy; 3. Mondaq; 4. Powerline; 5. NREL; 6. ST

Key smart energy technologies most relevant for Indonesia and seeing adoption are…

Indonesia

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Ultra-Fast EV Charging Station, Bali

Name of the technology: Ultra-Fast Charging

- **Project description**: In March 2022, President Joko "Jokowi" Widodo inaugurated Indonesia's first ultra-fast electric vehicle (EV) charging station in Nusa Dua, Bali. This project, developed by the state electricity firm PLN, includes 60 ultra-fast charging stations and 150 home charging locations. The ultra-fast chargers can fully charge an EV in just 30 minutes.
- **Expected impact:** This project is expected to significantly reduce Indonesia's dependence on fossil fuels, promote the use of electric vehicles.

02

Brief case study -2 - East Kalimantan Microgrid

- **Name of the technology:** Microgrid
- **Project description**: Hitachi ABB Power Grids has successfully deployed Indonesia's largest microgrid solution at a mining facility in East Kalimantan. This microgrid integrates solar PV with BESS and advanced controls to ensure a continuous power supply for off-grid mining operations.
- **Expected impact:** The project is expected to reduce the mine's carbon footprint by 192 tonnes of CO2 annually, promoting sustainable mining practices. The system is designed to produce 230 MWh annually significantly reducing reliance on diesel generation & operational costs.

Source: 1. Government of Indonesia 2. Hitachi Energy

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Indonesia has the right environment in place to accelerate industrial decarbonization…

Indonesia

Policy	Incentives
• Indonesia has numerous policies that promote use of biofuels in the country. In addition to this, there are regulations to promote adoption of CCUS across industries	• The country has incentives in place to support the adoption of green technologies across industries

Infrastructure	Financing
• Indonesia has enabling infrastructure in the form of a plethora of pilot projects across decarbonization themes – companies like Pertamina are leading the charge.	• While there is a lack of direct government funding – other funds make up for the lack of the same (Example – Green Climate Fund)

Key Policies and Regulations

Blending Mandate Support (B35)	• Indonesia's B35 mandate, implemented in February 2023, requires a 35% biodiesel blend in road transport fuel, significantly increasing palm oil use for fuel. This initiative aims to enhance energy security and boost renewable energy usage.
Organization of CCS Activities (PR 14 / 2024)	• This regulation outlines the framework for Carbon Capture and Storage (CCS) activities, focusing on reducing carbon emissions and mitigating climate change impacts.
National Action Plan for reducing GHG Emissions	• This plan sets out strategies and measures to lower greenhouse gas emissions across various sectors, contributing to Indonesia's commitment to global climate goals.

Key Initiatives and collaborations

Tangguh CCUS R&D Initiative	• This initiative focuses on research and development in Carbon Capture, Utilization, and Storage (CCUS) at the Tangguh gas field, aiming to reduce carbon emissions and enhance sustainable energy practices.
Pertamina & Honeywell UOP Biofuel Production Project	• A collaborative project between Pertamina and Honeywell UOP to produce biofuels, which aims to create cleaner energy alternatives and reduce reliance on fossil fuels.
KADIN Net Zero Hub	• An initiative by the Indonesian Chamber of Commerce and Industry (KADIN) to support businesses in achieving net-zero emissions, promoting sustainable practices and environmental responsibility.

Key takeaways

- Indonesia has a comprehensive ecosystem supporting industrial decarbonization. Key policies and initiatives promote biofuels, carbon capture, and sustainable practices. Collaborative projects enhance innovation and environmental responsibility, driving the country's commitment to reducing greenhouse gas emissions and fostering a sustainable future.

Source: 1. Argus Media; 2. Mondaq; 3. IEA; 4. Offshore; 5. Honeywell; 6. Net Zero Hub

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Key Industries which will enable technology adoption in Indonesia are…

Indonesia

Key industries	Most relevant technologies
Power & Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Basic Metals	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Sector agnostic technologies	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation

Key technologies seeing activity in the country

01

Brief case study -1 - Arun CCUS Project

- **Name of the technology:** Carbon Capture & Storage
- **Project description**: The Arun CCUS project focuses on capturing and storing CO2 from natural gas processing facilities in the Arun field, Aceh. It is a collaborative effort involving Pertamina, ExxonMobil, and the Indonesian government. The project aims to utilize depleted gas reservoirs for CO2 storage, making it a significant step towards reducing carbon emissions in the region.
- **Expected impact:** This project is expected to significantly reduce carbon emissions, contributing to Indonesia's climate goals and enhancing the sustainability of natural gas operations.

02

Brief case study -2 - Pertamina Cilacap Biorefinery Project

- **Name of the technology:** Biofuels
- **Project description**: This project involves the development of a biorefinery at Pertamina's Cilacap and Plaju refinery units to produce 100% green biofuels, including green diesel & BioAvtur, using renewable feedstocks like palm oil. The project also aims to integrate advanced bio-refining technologies and collaborate with international partners to ensure the highest standards of sustainability.
- **Expected impact:** The biorefinery project aims to reduce reliance on fossil fuels, lower greenhouse gas emissions, and promote the use of sustainable energy sourcesz.

Source: 1. Energy Voice; 2. Oil & Gas Journal;

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Kazakhstan requires a greater push on financing of smart energy projects to ensure widespread adoption

Kazakhstan

Policy	Incentives
• The country is slowly transitioning towards renewable energy and other facets of smart energy driven by government policies that enable the same. More specific policies needed	• Kazakhstan is advancing towards incentivizing smart energy technology usage – however the type of incentives and variety is still at an emerging stage

Infrastructure	Financing
• Kazakhstan has taken steps towards developing infrastructure for smart energy solutions – though the scale is limited as on date	• Financing smart energy technologies is a challenge due to the country being heavily dependent on oil and gas revenues. Green investments are still very nascent

Key Policies and Regulations

Kazakhstan 2050 Strategy	• While the strategy is a broader country level strategy, it also emphasizes on energy efficiency and inclusion of renewable energy sources into the electricity grid of the country and has set targets for the same.
2020 Green Economy Concept	• The original policy (Concept for the Transition to a Green Economy) was launched in 2013 and set a target for the country to generate 50% of its electricity by 2050 from alternative or renewable sources, (gas and nuclear in addition to RES). In 2020, the government adopted an action plan for implementing the Green Economy Concept.
Renewable Energy Law	• This law provides a framework for promoting renewable energy in the country – has been amended multiple times and in recent years included elements on smart grid technology and moder energy infrastructure development.

Key Initiatives and collaborations

Astana International Finance Centre (AIFC) – Green Finance	• The AIFC Green Finance Centre promotes green finance and sustainable development, providing a structural framework for investments in smart energy projects, including smart grids. This initiative supports the integration of advanced technologies and innovation in Kazakhstan's energy sector.
KEGOC Smart Grid Modernization Initiative	• KEGOC's initiative aims to modernize Kazakhstan's electrical grid, enhancing its reliability, efficiency, and resilience. By incorporating smart grid technologies, this initiative facilitates better energy management and integration of renewable energy sources.
De-risking Green Finance – UNDP Initiative	• This initiative focuses on reducing investment risks in renewable energy projects, making it easier for private sector investments in smart energy solutions. It supports the deployment of smart grids by ensuring financial viability and sustainability of green energy projects.

Key takeaways

- Kazakhstan's smart energy ecosystem is in the early stages of development, with progress driven mainly by policy frameworks and pilot projects. However, challenges remain in scaling infrastructure, financing, and incentives, leaving widespread adoption of smart energy technologies relatively limited.

Source: 1. IEA; 2. IEA; 3. Astana Times; 4. GFC; 5. Kegoc; 6 UNDP

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

There is a lack of smart energy projects in the country as technology adoption is still picking up

Kazakhstan

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Automated Generation Control Pilot

Name of the technology: Automated Generation Control

- **Project description**: USAID has partnered with Kazakhstan to launch a pilot project aimed at securing regional and national electricity supplies. This innovative project involves an automated generation control (AGC) system that manages power flows in real-time, compensating for fluctuations.
- **Expected impact:** The pilot project is expected to reduce the impact of renewable energy variability on the power system, support Kazakhstan's renewable energy goals, and enable regional trade of flexible capacities.

02

Brief case study -2 - Environment & Ecology Park

Name of the technology: Smart Grids

- **Project description**: Shenzhen Energy Group Company will build an integrated environment and ecology park in Astana in Kazakhstan. The company, which has signed an agreement with the Astana city government, will explore renewables and smart energy project development opportunities.
- **Expected impact:** The project is expected to boost the integration of renewable energy and smart grid technologies. This will enhance energy efficiency, reduce carbon emissions, and support Kazakhstan's sustainable development goals.

Source: 1. USAID; 2. Kazakhstan Government

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Kazakhstan is still developing the landscape for industrial decarbonization and is currently emerging

Kazakhstan

Policy	Incentives
• Kazakhstan has established foundational policies for industrial decarbonization, but more robust enforcement and sector-specific measures are needed	• Financial incentives for decarbonization are limited, with some support available through international partnerships but lacking broad domestic initiatives

Infrastructure	Financing
• Industrial decarbonization infrastructure, such as for CCUS and green hydrogen, is in early development, with few large-scale implementations	• International financing drives most industrial decarbonization projects, but domestic funding remains insufficient for scaling these technologies

Key Policies and Regulations

The Strategy on Achieving Carbon Neutrality by 2060	• This strategy aims to achieve carbon neutrality by 2060 through significant reductions in greenhouse gas emissions, promoting renewable energy, and enhancing energy efficiency across all sectors.
Kazakhstan National Emissions Trading System (ETS)	• Kazakhstan's ETS, launched in 2013, sets a cap on CO2 emissions for major industrial sectors, allowing companies to trade emission allowances to incentivize cost-effective emission reductions.
Draft Hydrogen Strategy	• Kazakhstan's Draft Hydrogen Strategy focuses on developing a robust hydrogen economy by investing in low-carbon hydrogen production technologies and integrating hydrogen into the national energy mix to support long-term decarbonization goals.

Key Initiatives and collaborations

KMG & Chevron - MoU	• KazMunay Gas(KMG) and Chevron Corporation signed a MoU to explore potential projects in the field of reducing carbon emissions in Kazakhstan. KMG and Chevron plan to explore potential opportunities for implementing joint projects in the field of carbon capture, utilization and storage (CCUS), the use of low-carbon hydrogen, the management of methane emissions and leaks, etc..
MoU between EBRD & KMG on decarbonization	• On June 8, 2022, KazMunay Gas (KMG) and the European Bank for Reconstruction and Development (EBRD) signed a MoU to collaborate on decarbonization. This partnership focuses on areas like low-carbon hydrogen energy, carbon capture, and energy efficiency.
EU Strategic partnership with Kazakhstan (Green Hydrogen)	• The EU and Kazakhstan have formed a strategic partnership to secure a sustainable supply of raw materials, develop renewable hydrogen, and enhance battery value chains. This collaboration aims to support the green and digital transformation of both economies.

Key takeaways

- Kazakhstan's industrial decarbonization ecosystem is in the early stages of development, with growing international collaborations but limited domestic infrastructure and incentives. More robust policies and financing mechanisms are needed to scale up decarbonization efforts across heavy industries.

Source: 1. European Commission; 2. ICAP; 3. Kazakhstan Govt; 4. KMG; 5. Hydrogen Insight

While there are a few marquee projects, from an adoption point of view, Kazakhstan is still a laggard

Kazakhstan

Key industries

- Power & Utilities
- Chemicals and Chemical Products
- Transport
- Basic Metals
- Sector agnostic technologies

Most relevant technologies

- Post-combustion: chemical absorption (biomass with CCUS
- Co-firing of ammonia in coal power plants
- Linear Fresnel reflector (solar)

- Biomass gasification to produce ammonia
- Synthetic hydrogen-based fuels in a conventional steam cracker
- Methanol via a catalytic conversion process

- High temp based PEMFC
- Ammonia-fuelled ship engine
- Hydrogen-fuelled urban transit bus and trucks

- Electricity in the Bayer process - Aluminium
- Hydrogen based DRI – Iron & Steel
- Improved ore refining methods (DRI)

- Biorefining
- Biomass gasification and catalytic methanation (biomethane)
- Synthetic fuel production with chemical methanation

Key technologies seeing activity in the country

01

Brief case study -1 - Hyrasia One

- **Name of the technology:** Green Hydrogen
- **Project description**: Hyrasia One, led by the European SVEVIND Energy Group, is one of the world's largest green hydrogen projects. It involves creating a wind-solar-hydrogen plant in Kazakhstan to produce up to 2 million tons of green hydrogen annually. The project will utilize renewable energy sources to power electrolysis for H2 production.
- **Expected impact:** The project aims to significantly contribute to global green hydrogen supply, supporting the decarbonization of various industries and positioning Kazakhstan as a key player in the renewable hydrogen market.

02

Brief case study -2 - SAF Production Feasibility Study

- **Name of the technology:** Sustainable Aviation Fuel
- **Project description**: KazMunayGas (KMG), Kazakhstan's national oil and gas company, is exploring the production of sustainable aviation fuel (SAF) in collaboration with Air Astana and LanzaJet. The project involves conducting feasibility studies and leveraging alcohol-to-jet (AtJ) technology to produce SAF, aiming to reduce the carbon footprint of aviation fuel.
- **Expected impact:** The project aims to establish a SAF production facility, contributing to Kazakhstan's carbon reduction goals and supporting Air Astana's target of using 25% SAF by 2060.

Source: 1. Hyrasia; 2. Safi Investor

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Mauritius needs stronger policies and incentives to boost smart energy development

Mauritius

Policy	Incentives
• Mauritius has set strategic goals in energy policy, focusing on renewables and smart technologies. Implementation, however, remains slow and inconsistent	• Incentives mainly target renewable energy projects like solar. Direct incentives for smart meters, grids, and EV infrastructure are still lacking

Infrastructure	Financing
• The country's smart energy infrastructure is underdeveloped, with some pilot projects for smart meters and grids, requiring significant upgrades	• International institutions primarily drive financing, with limited local funding options. More domestic support is needed to scale up projects

Key Policies and Regulations

10 Year EV Integration Roadmap	• The Electric Vehicle Integration Roadmap for Mauritius outlines a 10-year plan to boost EV adoption by addressing barriers and leveraging international best practices. It includes scenarios for 2030, assessing impacts on CO2 emissions, the electricity grid, and the economy.
Renewable Energy Strategic Plan (RESP)	• The Renewable Energy Strategic Plan (RESP) by MARENA outlines Mauritius' goals for increasing renewable energy adoption, enhancing grid technology, and promoting sustainable transportation to support the Government's Vision 2030.

Key Initiatives and collaborations

Maurice Ile Durable (MID) Fund	• An initiative introduced by the prime minister to build a resilient, green and sustainable country. A green loan facility has been set up in collaboration with the Agence Française de Développement, allowing commercial banks to offer preferential credit facilities to companies investing in green industries.

Key takeaways

- Mauritius is gradually building its smart energy ecosystem, though infrastructure and incentives remain limited. The country requires the government to law down new policies for distinct smart energy technologies. Increased focus on green finance and available financing mechanisms will also boost technology adoption within smart energy

Source: 1. Gov Mu; 2. Marena; 3. Intracen;

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

SE

Mauritius has piloted numerous microgrid projects and now needs to scale it up to fully harness the capabilities of smart energy systems

Mauritius

Relevant technology types	Most relevant technologies
Cross cutting: charging technologies	• Smart Charging • Fast and Ultra-fast charging • Inductive charging
Smart grid networks	• High Temperature Low Sag Conductors (HTLS) • Voltage source converters • Synchronous Condenser
Smart grid enabler– market mechanisms	• Virtual power plants • EV demand response • Industrial demand response for frequency balancing and voltage control
Digital technologies	• Digital Twin • Distributed ledger technology / Blockchain • AI and ML in distribution grid
Cross cutting: tracking and monitoring	• Automated and connected vehicles (level 4+) • Advanced monitoring technologies • Automated and connected ship

Key technologies seeing activity in the country

01

Brief case study -1 - Mauritian Wave & Microgrid

Name of the technology: Isolated Microgrid

- **Project description**: The Mauritian Wave and Microgrid project is a wave energy integrated hybrid power station for the Mauritian island of Rodrigues, consisting of solar PV and a battery energy storage system, with intelligent control systems to ensure reliable, utility grade power quality and grid stability.
- **Expected impact:** The project is expected to demonstrate effective integration of multiple renewable energy sources into an isolated grid, enhancing energy reliability and sustainability.

02

Brief case study -2 - Gas Insulated Switchgear Project

Name of the technology: Smart Grids

- **Project description**: Mauritius Gas Insulated Switchgear (GIS) Substation Project aims to undertake the necessary network expansion investments. This project is expected to address the vulnerability of the electricity grid to the effects of climate change and the lack of interconnection points for the absorption of renewable energy.
- **Expected impact:** The project development objective is to increase the reliability of the national grid and the number of injection points for renewable energy generating facilities.

Source: 1. PV Magazine; 2. Map Africa

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Increased focus on incentivizing the usage of industrial decarbonization technologies is the way to go for Mauritius

Mauritius

Policy	Incentives
• Mauritius' policy framework supports low-carbon development, but it lacks targeted policies for specific industrial decarbonization technologies like CCUS or green hydrogen.	• Financial incentives focus on general renewable energy adoption, with little support for specific industrial decarbonization technologies such as biofuels or green steel

Infrastructure	Financing
• Decarbonization infrastructure for heavy industries is minimal, with very few pilot projects. Large-scale investment is needed for green technologies	• Financing comes largely from international organizations, but there's limited local financial support or incentives to decarbonize heavy industries

Key Policies and Regulations

Renewable Energy Roadmap 2030	• The Mauritius Renewable Energy Roadmap 2030 aims to achieve 60% renewable energy in the energy mix by 2030, up from an initial target of 35% by 2025. It includes phasing out coal and implementing various renewable energy schemes to support this transition.
Marine Energy Roadmap for Mauritius	• A roadmap for marine energy resource development in Mauritius. This roadmap evaluates three renewable energy technologies that the Mauritius Research Council has identified as being of practical interest: offshore wind power, wave power, and sea water air conditioning (SWAC).
Long Term Energy Strategy 2025	• This document is a guide towards the development of the energy sector up to year 2025. It lays emphasis on the development of renewable energy, reduction of dependence on imported fossil fuel and the promotion of energy efficiency in line with government's objective to promote sustainable development.

Key Initiatives and collaborations

Sustainability and Climate Change Programme (SCCP):	• The University of Mauritius (UdM) Sustainability and Climate Change Programme conducts applied research on sustainability and climate change. It integrates economy, society, environment, and governance to support policy decision-making and fosters transdisciplinary collaborations to address real-world challenges.
Partnership for Action on Green Economy (PAGE)	• The Partnership for Action on Green Economy (PAGE) has supported Mauritius since 2014 in transitioning to a green economy by enhancing national policymaking, sectoral reforms, and capacity building.
Facilité 2050:	• The 2050 Facility, established by the Agence Française de Développement (AFD), supports around 30 high-emission and vulnerable developing countries in transitioning to low-carbon and resilient development models. It provides grants for studies, capacity-building activities, and climate policy dialogue to help the countries.

Key takeaways

- Mauritius is making initial strides in industrial decarbonization, however more infrastructural and financial support is needed. International partnerships will play a critical role in driving decarbonization efforts forward.

Source: 1. UNSDG; 2. Gov Mu; 3. Gov Mu; 4. SCCP; 5. UN-PAGE; 6. AFR

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

A2D Accelerate to Demonstrate Facility

ID

Presently, Mauritius needs to adopt decarbonization technologies quicker in order to meet their GHG emission reduction goals

Mauritius

Key industries	Most relevant technologies
Power & Utilities	• Post-combustion: chemical absorption (biomass with CCUS • Co-firing of ammonia in coal power plants • Linear Fresnel reflector (solar)
Chemicals and Chemical Products	• Biomass gasification to produce ammonia • Synthetic hydrogen-based fuels in a conventional steam cracker • Methanol via a catalytic conversion process
Transport	• High temp based PEMFC • Ammonia-fuelled ship engine • Hydrogen-fuelled urban transit bus and trucks
Basic Metals	• Electricity in the Bayer process - Aluminium • Hydrogen based DRI – Iron & Steel • Improved ore refining methods (DRI)
Sector agnostic technologies	• Biorefining • Biomass gasification and catalytic methanation (biomethane) • Synthetic fuel production with chemical methanation

Key technologies seeing activity in the country

01

Brief case study -1 - Accelerating the Transition to a Net-Zero Nature-Positive Economy in Mauritius (NZNPA)

- **Name of the technology:** Multiple
- **Project description**: The "Accelerating the Transition to a Net-Zero Nature-Positive Economy in Mauritius" (NZNPA) Project aims to decarbonize the manufacturing sector, enhance productivity, and establish an enabling environment for integrating nature-based solutions.
- **Expected impact:** The project is expected to boost national competitiveness and sustainability, while significantly reducing carbon emissions and promoting biodiversity.

02

Brief case study -2 - Ocean thermal energy conversion (OTEC) project

Name of the technology: Thermal Energy Conversion

- **Project description**: The Ocean Thermal Energy Conversion (OTEC) project by Mitsui O.S.K. Lines (MOL) in Mauritius aims to generate electricity by utilizing the temperature difference between warm surface water and cold deep ocean water.
- **Expected impact:** Successful commercialization of OTEC technology by 2026, contributing to Mauritius' goal of increasing renewable energy usage to 60% by 2030.

Source: 1. Gov Mu; 2. Offshore Energy

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

+43 1 26026-0

https://a2dfacility.unido.org

A2DFacility@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION