GLOBAL CCS INSTITUTE

Submission of views on opportunities, best practices, actionable solutions, challenges and barriers relevant to "Cities, buildings and urban systems."

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The Institute presents this document as contribution to the ongoing dialogue on carbon capture utilization and storage (CCS), as was seen in last year's first global dialogue and its associated annual report of findings. As we collectively strive to mitigate climate change and achieve the objectives outlined in the Paris Agreement, it is imperative to explore and leverage the potential of Carbon Capture, Utilization, and Storage technologies.

Cities, buildings, and urban systems are significant contributors to global carbon emissions, making them focal points for effective climate action. CCS offers a promising pathway to significantly reduce carbon emissions from these sources while fostering sustainable development. This submission therefore outlines our views, opportunities, best practices, actionable solutions, as well as the challenges and barriers associated with the implementation of CCS in urban environments.

The Institute looks forward to continued engagement with the UNFCCC, Parties and Observer Organizations to advance discussions and actions related to CCS in such contexts.

Spotlight: Cement and Concrete

For some industries, especially cement production and waste incineration, capture and storage of CO_2 is the only way to remove all greenhouse gas emissions. The cement and concrete sector presents an important avenue for mitigating emissions, being one of the largest emitters of CO_2 globally due to the energy-intensive processes involved in cement production, which is a key component of concrete. The process involves heating limestone (calcium carbonate) to produce lime (calcium oxide), releasing CO_2 as a byproduct. CCS can be applied at various stages of cement production to capture emissions with post-combustion capture, pre-combustion capture, and oxy-fuel combustion being some of the common methods explored. Once CO_2 is captured, it can be compressed, transported, and stored underground in geological formations such as depleted oil and gas reservoirs or saline aquifers.

Opportunities

Economic Development and Successful Supply Chains: The deployment of CCS infrastructure presents a significant opportunity for job creation, economic growth, and technological innovation within urban areas. Investments in CCS projects can stimulate local economies while simultaneously advancing climate goals. A successful supply chain is key to creating and sustaining high-skill, high-value jobs and supporting low-carbon growth in industrial clusters.

Co-Benefits for Urban Life: CCS implementation can yield co-benefits beyond emissions reduction, such as improved air quality, enhanced energy security, and increased resilience to climate impacts. Leveraging these co-benefits can garner broader support for CCS initiatives among urban stakeholders.

Innovation: Investing in CCS research and development plays a critical role in unlocking the full potential of carbon capture technologies to address climate change mitigation goals while fostering sustainable economic development and industrial decarbonization. This includes developing advanced capture and storage technologies, utilization pathways, integration and system optimization and policy and business models.

Best practices
Environmental, economic and socially sound CCS deployment can benefit from a number of best practices, these include:

International and Regional Regulations:

- The IPCC GHG Inventory Guideline 2006 (Vol 2 Energy, Capture 5: CO2 Transport, Injection and Geological Storage) includes monitoring methods and leakage risk assessment.
- The 2009 EU CCS Directive establishes a legal framework for the environmentally safe geological storage of CO_2, where no geological storage of CO_2 will be possible without a storage permit. It covers all CO_2 storage in geological formations in the EU and the entire lifetime of storage sites, with provisions on the capture and transport components of CCS. Australia regulates greenhouse gas storage under the Offshore Petroleum and Greenhouse Gas Storage Act 2006. Through this regulation, based on industry nominations and public, government and stakeholder consultation, the government announced the 2023 offshore greenhouse gas storage acreage release areas across 7 basins. The release begins the process by which companies are ~~a~~ awarded a title giving them rights to explore the geology in an area in a structure, transparent and well-regulated way.
- The United States regulatory environment for CCS includes regulations for CO_2 storage on private land (Underground injection Control "Class VI"), CO_2 storage on federal land and CO_2 pipeline safety.

Inter-governmental Collaboration: The Carbon Management Challenge (CMC) is focused on the principle of collectively managing 1 Gigaton (Gt) or more of CO_2 annually by 2030 and has the potential to play a vital role in unlocking CCS deployment challenges. CMC joiner countries represent global diversity and include members from all major regions of the world, countries with different energy supply profiles and from developed and emerging economies. The CMC builds on the work of the Clean Energy Ministerial (CEM) CCS Initiative, aimed at accelerating CCS through facilitating knowledge on technologies, regulations, and policies, and leading strategic partnerships to accelerate both near and longer-term investment in CCS.

Public-Private Partnerships: Successful CCS projects often involve partnerships between governments, industry stakeholders, research institutions, and civil society to leverage expertise and resources effectively. Governments can collaborate with industry stakeholders through public-private partnerships to co-fund CCS projects and share risks. By leveraging public funds with private sector expertise and resources, governments can accelerate the deployment of CCS technologies and maximize the impact of public investment. Examples of public-private partnerships include:

- Project LEILAC (Low Emissions Intensity Lime and Cement) is a collaborative effort involving several partners from industry, research institutions, and government agencies aimed at developing and demonstrating carbon capture technology specifically tailored for the cement and lime industries. In order to reach the required 80% emissions reductions in the EU by 2050, CCS will need to be applied to 85% of European clinker production, and LEILAC aims to allow Europe to achieve these targets in a timely, effective and efficient manner. The project aims to develop and demonstrate viable carbon capture solutions to reduce emissions from cement and

lime production, that will enable Europe's cement and lime industries to reduce their emissions dramatically while retaining, or even increasing, international competitiveness. LEILAC will develop, build and operate a 240 tonne per day pilot plant demonstrating Direct Separation calcining technology which will capture over 95% of the process CO_2 emissions (which is 60 % of total CO_2 emissions) from both industries without significant energy or capital penalty. To accelerate further development, LEILAC will deliver a techno-economic roadmap, and comprehensive knowledge sharing activities including a visitor centre at the pilot site near Brussels.

- Northern Lights in Norway is an industry joint venture transporting aimed at transporting and storing CO_2 to offshore storage sites beneath the North Sea as part of the government's project Longship. By bringing together industry players, government support, technology providers, and international collaboration, the project demonstrates a holistic approach to tackling CO_2 emissions and accelerating the transition to a low-carbon future.
- The Port of Rotterdam CO_2 Transport Hub and Offshore Storage "Porthos" project in the Netherlands, is a significant initiative aimed at developing CCS in one of Europe's largest industrial clusters. The primary objective of the Porthos project is to establish a CO_2 transport and storage infrastructure that enables industrial facilities in the Rotterdam port area to capture CO_2 emissions and transport them offshore for permanent storage beneath the North Sea. The project is led by a consortium of partners from industry with the Port of Rotterdam Authority, where support included funding from the Dutch government with a guaranteed EUR 2.1 billion in funding over 15 years, even though support might be considerably lower considering rising EU-ETS prices. Construction commences in 2024, and operations in 2026, with the aim to store 2.5 $MtCO_2$ per year over 15 years.
- Net Zero Teeside is a collection of industrial, power and hydrogen businesses which aim to decarbonize their operations through the deployment of CCS in the UK.

Government Policies: Several governments have recognized the importance of CCS in mitigating greenhouse gas emissions and have implemented tailored policies to support its development and deployment in their country and/or region. Examples include:

- **Canada**: Canada's current federal emissions reduction plan expects national CCS capacity to more than triple, adding facilities to capture and store at least 15 million tonnes per year by 2030.The federal government has also announced funding programs, such as the Strategic Innovation Fund and the Clean Fuels Fund, which support CCS projects. Additionally, provinces such as Alberta have established specific policies and regulations to support CCS development.
- **European Union**: the EU has been actively pursuing CCS policies and initiatives to decarbonize the industrial sector as part of its broader climate objectives, where it is clear that the decade up to 2040 will need to see remarkable growth of carbon capture capacity. Current actions include:
    - The Fit for 55 package to reduce emissions in the EU by at least 55% by 2030, with measures and modifications that support CCS deployment.
    - The EU Industrial Carbon Management Strategy, which outlines measures to Scaling up CCS to align with the EU's 2040 climate target, targeting an annual CO2 injection capacity of at least 250 million tonnes per year in the European Economic Area (EEA) by 2040. This comes in addition to the EU-wide target set

out in the Net-Zero Industry Act to establish 50 million tons of annual CO_2 storage capacity by 2030.
    - Innovation Fund that has supported projects related to CCS, where in the third call in July 2023, 11 out of the 41 projects funded include a CCS, CDR or CCU component.
    - In the EU Emissions Trading Scheme (ETS), CCS installations are explicitly included, with modifications made through the Fit for 55 Package.
- **Indonesia**: The Indonesian Government has pledged to achieve net-zero by 2060 with an estimated 400 to 600 GT of CO_2 storage capacity. Indonesia issued a presidential regulation on carbon capture and storage, providing a framework to support the country's vision of being a leading CCS/CCS hub by facilitating the import of CO_2 into Indonesia from other countries, where operators can set aside 30% of their storage capacity for imported CO_2.
- **United Kingdom**: Since 2021, the UK have established the roll-out process and identified the first four CCS clusters for deployment in the UK by 2030. The government has committed up to £20 billion to establishing a CCUS sector in the UK, which will help unlock economic opportunities and will include significant investment in CCUS projects supporting up to 50,000 jobs. CCS is a key component of the UK's climate strategy, as outlined in the Ten Point Plan for a Green Industrial Revolution, with an aim to capture 10Mt of carbon dioxide a year by 2030. The UK government has announced funding for CCS projects through initiatives like the Industrial Decarbonization Challenge and the Carbon Capture, Usage and Storage Infrastructure Fund.
- **United States**: The Infrastructure Investment and Jobs Act enacted in August 2022 includes significant funding for CCS projects, research, and infrastructure development. Additionally, the 45Q tax credit provides financial incentives for CCS projects.

Challenges and Barriers

While several ecological considerations exist, similar to that of most mitigation technologies, including but not limited to habitat disruption, land use changes, and resource consumption, this requires a universally conscious approach to how humanity decides to use all types of man-made technologies, and to what extent, based on a balance of environmental and societal needs. Destructive impacts can however be immediately minimized through careful siting and design measures, with the active engagement of local communities.

The following challenges and barriers presented below are the most uniquely specific to CCS deployment:**Infrastructure and Regulatory Requirements**: CCS deployment requires extensive infrastructure for capturing, transporting, and storing CO_2, including pipelines, compression facilities, and access to geological storage sites. The lack of corresponding supportive policies and regulatory frameworks can hinder CCS deployment by creating uncertainty for investors and project developers. International regulations, notably the London Protocol, also need further ratification in order to come into force and facilitate cross-border transfer of CO_2.

Cost: The cost of CCS can vary depending on several factors including technology used, project scale, location and regulatory environment.

Public Acceptance: Public perceptions and acceptance of CCS technologies can influence project feasibility and implementation. Concerns about safety, environmental impacts, land-use considerations and risks associated with CO_2 storage may lead to public opposition.

Actionable Solutions
Addressing the above challenges and barriers requires a coordinated effort involving government, industry, academia, and civil society. Supportive action to accelerate the deployment of CCS include:

Challenge: Infrastructure and Regulatory Requirements
Ratification of the London Protocol Amendments: The London Protocol is an international agreement that regulates the cross-border transfer and offshore subsurface storage of carbon dioxide and other industry by-products. It has been signed by 53 countries, plus the European Union. In 2009, Contracting Parties adopted a formal amendment to Article 6 of the Protocol, which had previously prohibited the transboundary movement of CO_2 for the purposes of geological storage. Notwithstanding the adoption, fewer than the required two thirds of countries have ratified the 2009 amendments in order to put them into force. In October 2019, this impasse was addressed when the Parties reached agreement to allow for the provisional application of the amendment to Article 6, which will allow proponents wishing to transport CO_2 across international boundaries, to proceed, provided they submit a declaration of provisional application and notification of any arrangements to the International Maritime Organization (IMO), and provided they meet the standards prescribed by the Protocol. The governments of Norway, Denmark and the Netherlands have deposited declarations stating their intent to allow the provisional application of the 2009 amendments. Read the Institute's perspective on national responses to CCS under the London Protocol here.

Challenge: Infrastructure and Regulatory Requirements
Policy Support: Clear and supportive policy frameworks are essential to incentivize investment, overcoming barriers and accelerating deployment of CCS technologies. Policy mechanisms may include carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, including through the operationalization of Article 6 and the establishment of regulatory frameworks that facilitate the permitting, licensing, and operation of CCS projects. Read the Institute's overview of organisations and policies supporting the deployment of large-scale CCS facilities here.

Challenge: Cost
Investment Incentives: Governments may offer financial incentives, grants, or subsidies to support the development, demonstration, and deployment of CCS projects. These incentives can help offset the high upfront costs associated with CCS infrastructure and encourage private investment in carbon capture and storage technology. Read the investment case for CCS by the Institute here.

Challenge: Public Acceptance
Capacity Building and Knowledge Sharing: Capacity building initiatives, including sharing of data, workforce training and education programs, should be implemented to enhance technical expertise in CCS technologies and project management. The further establishment of CCS Centres of Excellence can enhance the dissemination of best practices, lessons learned, and success stories from CCS projects around the world.

Challenge: Public Acceptance
Securing Social License: Meaningful engagement with local communities and stakeholders is crucial to building public acceptance and trust for CCS projects, addressing concerns, and

ensuring transparency throughout the process. This can help further collective understanding of the use of CCS and its performance in supporting the environment and society. Public engagement may include Public Consultation and Stakeholder Engagement Workshops, organized by a government agency and/or a project developer to actively involve local communities, stakeholders and the general public on decision-making processes regarding CCS projects. Steps may involve the following:

1. Objective Setting: Clearly defining the objectives, scope, and goals of the CCS project. This includes identifying the potential benefits and risks associated with the project and understanding the concerns and priorities of stakeholders.
2. Information Sharing: The organizers provide accessible and transparent information about CCS technology, project plans, potential impacts, and regulatory frameworks. This information is disseminated through various channels, including public meetings, workshops, online platforms, informational materials, and media outreach.
3. Dialogue and Feedback: Opportunities for two-way communication between project developers, experts, and the public. Participants are encouraged to ask questions, share their perspectives, and provide feedback on the CCS project. Facilitated discussions and/or surveys allow stakeholders to express their concerns, interests, and preferences regarding project siting, safety measures, environmental impacts, and community benefits.
4. Addressing Concerns: Project organizers actively listen to the concerns and feedback raised by stakeholders and address them transparently and comprehensively. They provide evidence-based responses, clarify misunderstandings, and discuss measures to address potential risks and challenges associated with the CCS project. This helps build trust and credibility with the public and stakeholders.
5. Collaborative Decision Making: The public engagement process aims to foster collaboration and consensus-building among stakeholders. Participants are encouraged to work together to identify solutions, alternative approaches, and opportunities to maximize the benefits and minimize the risks of the CCS project. This collaborative approach ensures that the project reflects the interests and values of the communities affected by it.
6. Continuous Engagement: Public engagement is an ongoing process that continues throughout the lifecycle of the CCS project. Project organizers regularly update the public and stakeholders on project progress, milestones, and developments. They remain open to feedback, address emerging concerns, and adapt project plans based on changing circumstances and stakeholder input.

A comprehensive overview of the milestones for carbon capture and storage can be found in the Institute's annual Global Status for CCS Report. Read the 2023 report here.