
CITY CDR INITIATIVE
Building Carbon Sink Cities

# Municipal Playbook

## Managing the Logistics of Urban Carbon Removal

## CONTENT



## CONTEXT

Carbon dioxide removal (CDR) are human-initiated activities that remove $CO_2$ from the atmosphere and durably store it in geological, terrestrial, or ocean reservoirs, or in products. According to the Intergovernmental Panel on Climate Change (IPCC), the world needs to remove gigatonnes of carbon removal annually by 2050 to meet the temperature goals agreed in the Paris Agreement. Logistics is indispensable for realizing CDR at scale.

## THE BIG IDEA

Local governments can accelerate the scale-up of carbon removal activities on their territory by taking an enabling role in the logistics. Planning and managing project supply chain related infrastructure and logistics needs for the carbon, raw materials and end-products at an early stage maximizes efficiency, reduces risks, and lowers costs. By supporting developers with the logistics of CDR projects, local governments can help accelerate carbon removal.

Project developers and investors often overlook the role of logistics at the project design stage (McKinnon, A. C., 2024). This risks causing incomplete designs of policies, projects, and investment strategies, and hampering the deployment of CDR and local workforce development. As local governments become more engaged in supporting local CDR project development, this Playbook helps prepare them for a more active role in facilitating the logistics, supply chains and infrastructure needed for different deployment pathways.

Building on the City CDR Initiative's report series *'Pathways to Carbon Sink Cities',* the Playbook describes the logistical context and governance of urban CDR, zooming in on public intervention needs and opportunities, before unpacking three different urban CDR pathways - biomass for construction, biochar for construction, and mineralizing $CO_2$ for construction. It concludes with guidance on how to manage the logistics of carbon removal in cities.

## DEFINING URBAN CDR LOGISTICS

Logistics relies on physical and digital infrastructure, transport and handling equipment, and ultimately a skilled workforce to deliver the services that keep the supply chain flowing. While the provision of logistics services are largely the domain of the private sector, the infrastructure they rely on is often publicly owned and/or managed, and their activities may, to different levels, be subject to national and local regulation. Supply chains include the actors, assets, and processes needed to deliver a good or service, from sourcing materials to the delivery of the (low carbon) product and/or realization of the carbon removal.

There is no single definition of the 'services' that are part of logistics. For the purpose of the CDR logistics, logistics can generally be considered to include the following:

- **Freight operations** - loading, transporting, unloading along a coordinated supply chain.
- **Packaging** - making materials and products suitable for transport or storage.
- **Sorting** - sorting waste streams used as feedstock in carbon removal processes.
- **Labelling** - enabling traceability and guiding handling along the supply chain.
- **Warehousing** - storing correctly to ensure material quality and support cost-efficiency.
- **Inventory management** - having the right material in the right place at the right time.
- **Compliance -** ensuring regulatory compliance, e.g., when handling dangerous goods.
- **Data flows** - digital information flows amongst supply chain partners.
- **Export/import** - managing customs procedures and organizing insurance.

Important decisions must be made along urban CDR supply chains to ensure cost-efficient, continuous and sustainable operations. Local governments have a vital role. This applies to decisions where private sector entities are project owners, the local government is the project lead, or the project uses public utility infrastructure in which a CDR method is integrated. Examples of public utility infrastructure include waste-water treatment plants (WWTPs), waste management or energy management infrastructure, and disaster resilient infrastructure (DRI).

## TAKING A PUBLIC ROLE

Local governments have many options to support the logistics involved in the development of urban CDR. They can act as critical enablers, bridging technology deployment with community needs and local ecosystems, while facilitating cross-border logistics needs.

## STEP 1

### Identify your logistics role

Local decisionmakers must take responsibility. Certain municipal competences are indispensable for urban CDR development. In other cases, public sector involvement adds value but is optional. Taking responsibility starts with mapping the role of the public sector in the context of supply chain elements, management needs, infrastructure requirements, and underpinning logistics of the carbon, raw materials, and end-products on the city's territory. This grounds the design of public interventions that support the logistics needs of specific CDR methods, deployment pathways and projects.

## STEP 2

### Secure stakeholder buy-in

Once the local government has identified its contribution opportunities and responsibilities, it should align with key stakeholders. Early consideration of urban CDR logistics must be done together with project developers, service providers, labor unions, affected communities, and other relevant stakeholders. This promotes buy-in, prevents bottlenecks, minimizes cost, reduces the environmental and social footprint, and informs timely workforce development. Local governments can mandate project developers and operators to share a transportation plan early on to come up with solutions to manage such aspects as traffic disruption or temporary storage needs in the urban environment.

## STEP 3

### Build the public toolkit

Important areas that local governments can leverage to facilitate the logistics of urban CDR projects revolve around:

- **Public instruments:** Strategic zoning; streamlining permits; changing construction and product standards; changing building standards; changing end-of-life rules; defining green procurement policies; creating regulatory sandboxes.
- **Public assets:** Identifying and facilitating the integration of CDR in public works; leveraging existing and building new shared infrastructure for transport and storage; providing access to public energy and water utilities.
- **Public funding:** Funding pilot projects; supporting public utility companies to fund CDR integration; funding public-private research initiatives; funding dedicated public-private urban CDR logistics coordination platforms.
- **Public engagement:** Engaging local communities; developing specialized local workforce; initiating citizen education campaigns.

In practice, different urban CDR deployment pathways have different logistics needs. These often extend far beyond the municipal borders and its legal and political competences. This is true for projects themselves, where the $CO_2$ capture, transport and storage, feedstock and other inputs for urban CDR applications, often do not all occur within the city, but even more when looking at the full value chain. Decision makers can engage neighboring municipalities and inform higher-level decision-making when dealing with regional, national or global supply chains or with activities that require adequate regulation and licensing on the federal and cross-border level.

## BUILDING CDR SUPPORT INFRASTRUCTURE

Developers' expectations from local governments on the provision of hard infrastructure focuses on instances where they can provide access to critical supply chain assets that are beyond the developers' individual ability to secure or where the local government has explicit ownership rights. Their enabling role however extends beyond ensuring fair access to traditional public infrastructure assets and maintaining adequate zoning and land-use rules within the city, and includes advocacy to shape regional and national strategies.

To build urban CDR supply chains and their logistics systems, several areas of decision-making around hard infrastructure are likely to involve local governments:

- **Siting choices** – Where is it possible and efficient for the supply chain to locate its different stages? How can cities help mobilize land, repurpose areas and revise zoning codes in favor of urban CDR?
- **Infrastructure design** – What productive, energy, water and transport infrastructure is needed to embed new CDR supply chain activities into existing urban systems? How can local governments help mobilize the diverse owners and operators, especially of energy and transport infrastructure, to support efforts?
- **Mode choices** – Which transport modes are available and accessible in and around the city, to connect the supply chain most efficiently? How can cities help develop access to transport services that are required for urban CDR to scale at minimal footprint?

For local governments, it is critical to understand how they can enable access to public infrastructure (road, rail, water), leverage 'specialized' infrastructure assets for CDR (WWTP, WtE plants, ports), including opportunities for development of CDR as a public utility. This includes the potential to invest in additional forms of hard infrastructure within the city borders or under its jurisdiction, such as building new roads, special holding facilities, or localized grids, reopening freight train stations, developing waterway infrastructure for freight handling, fortifying bridges, or expanding port infrastructure. This will often require funding coordination with neighboring municipalities and higher level governments.

## CONCLUSION

Many CDR methods have yet to be deployed in urban environments at scale. This is particularly true for the more permanent methods. They often involve complex systems, feedstock, infrastructure, and workforce needs, and novel rulemaking to make the economics 'work'. This is where local governments are needed; to help connect the dots.

Local governments can improve the logistics of urban CDR supply chains in meaningful ways. It is important for the scale up of urban CDR that they equip themselves adequately. Whether through zoning, regional coordination or influencing national planning, local governments have the tools to support increasingly efficient supply chains that limit social and environmental externalities, bring down costs and increase the commercial viability of urban CDR projects.

Local leaders can make logistics systems a pillar of its climate planning and governance. By building the capacity to act on logistics infrastructure and services, local governments can become meaningful partners of developers, investors and higher level governments, engage in long-term climate infrastructure planning and protect the interests of its residents.

# ANNEX: URBAN CDR LOGISTICS - CASE STUDIES

| 1. Biomass for Construction | |
|---|---|
| **Bio-based building materials can be used in load-bearing, non-load-bearing, insulation, and finishing components of buildings. Carbon is stored in solid form for the lifetime of the product. Bio-based building materials, such as wood, bamboo, straw, hemp, flax, reeds, and typha, are natural materials derived from living organisms and are therefore renewable. When incorporated into buildings for periods exceeding the material's natural regeneration cycle, it turns the structure into a carbon sink.** | |
| **Supply Chain** | **Description** |
| **Sourcing raw materials** | • Coordinating supply chains for the right quantities of the right quality at the right time.<br>• Transporting raw materials from farms, forests, public lands to production sites. |
| **Harvesting and processing** | • Providing adequate storage to even out seasonal cycles of production and consumption. |
| **Manufacturing bio-based building materials** | • Performing careful quality control and testing to meet regulatory and safety standards.<br>• Integrating supply chains and manage inventory to multiple supplies. |
| **Warehousing** | • Packaging materials to protect them from impacts during transport and storage.<br>• Managing warehousing at key locations between production and demand centers.<br>• Optimizing inventory and shipping frequencies, transportation routes and modes to minimize carbon emissions.<br>• Ensuring accurate documentation to customs authorities if sourced internationally. |
| **Distribution to retailers or construction projects** | • Aligning production schedules with project timelines between supplier, manufacturer, and construction teams.<br>• Aligning logistics with construction schedules with just-in-time delivery or bulk delivery to project sites. |
| **Installation and construction** | • Minimizing waste during the construction process.<br>• Ensuring timely delivery of bio-based materials to construction sites. |
| **End-of-life management** | • Managing end-of-life needs and planning post-use life specific to the bio-based materials.<br>• Enabling building disassembly instead of demolishing for material recovery and reuse.<br>• Monitoring and reporting the carbon footprint reduction achieved by using biochar-based materials. |

## Logistics challenges

- Biomass feedstocks are often geographically dispersed and subject to seasonal availability, causing inconsistent supply and fluctuating costs.
- Transport and handling of timber for construction may require special consideration in urban traffic
- Access to adequate workforce requires proximity to places with population density, which tends to be at odds with the location of large-scale farming.
- The decentralized consumption of the natural fiber construction materials and end-products adds shipping costs and emissions.

## Specific municipal support

- Use zoning powers to enable co-location with a renewable energy production plant, warehouses, and infrastructure nodes.
- Evaluate options for timber transfer terminals and quays located along existing rail and waterway infrastructure.
- Supply raw materials from municipal owned land and coordinate with surrounding municipalities to centralize collection and storage as biomass feedstocks.
- Regulate the diversion of bio-based materials pre-landfill or incineration.

## 2. Biochar for construction

**Secondary biomass is sourced to produce biochar which is used as a filler or partial replacement for cement and fine aggregates in cement-based materials. Carbon is physically embedded in long-lived structures, creating a carbon sink and reduces the carbon footprint of buildings and road infrastructure.**

| Supply Chain | Description |
|---|---|
| **Sourcing raw materials** | • Coordinating supply chain for the right quantities of the right quality at the right time.<br>• Transporting raw materials from farms, forests, public lands to the production facilities. |
| **Harvesting and production** | • Providing adequate storage to even out seasonal cycles of production and consumption. |
| **Processing and quality control** | • Ensuring biochar meets specific standards regarding porosity, density, and moisture content.<br>• Performing careful quality control and testing to meet regulatory and safety standards of biochar material. |
| **Warehousing** | • Packaging materials to protect them from impacts during transport and storage.<br>• Managing warehousing at key locations between production and demand centers<br>• Optimizing inventory and shipping frequencies, transportation routes and modes to minimize carbon emissions.<br>• Ensuring accurate documentation to customs authorities if sourced internationally. |

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| **Distribution to retailers or construction projects** | • Aligning production schedules with project timelines between supplier, manufacturer, and construction teams.<br>• Aligning logistics with construction schedules with just-in-time delivery or bulk delivery to project sites. |
| **Installation and construction** | • Minimizing waste during the construction process.<br>• Ensuring timely delivery of bio-based materials to construction sites. |
| **End-of-life management** | • Managing end-of-life requirements and plan post-use life specific to the bio-based materials.<br>• Enabling building disassembly rather than demolishing to facilitate material recovery and reuse.<br>• Monitoring and reporting the carbon footprint reduction achieved by using biochar-based materials. |

## Logistics challenges

- Biomass feedstocks are often geographically dispersed and subject to seasonal availability, causing inconsistent supply and fluctuating costs.
- Transport and handling of timber for construction may require special consideration in urban traffic
- Access to adequate workforce requires proximity to places with population density, which tends to be at odds with the location of large-scale farming.
- The decentralized consumption of the natural fiber construction materials and end-products adds shipping costs and emissions.

## Specific municipal support

- Use zoning powers to enable co-locating biochar reactors with renewable energy production plants, warehouses, and infrastructure nodes.
- Supply raw materials from municipal owned land, coordinate access with surrounding municipalities, and enable sewage sludge supplies from publicly owned WTTP.
- Regulate the diversion of bio-based materials pre-landfill or incineration.

## 3.Mineralizing $CO_2$ for building materials

**Atmospheric or biogenic $CO_2$ is captured and chemically converted into carbonate minerals for use in building materials, such as carbonated aggregates, carbon-negative concrete, or carbon-based binders. $CO_2$ can be captured at a plant and transported, or from the atmosphere or indoor air directly into the material. Concrete, a $CO_2$ sink readily manufactured in urban settings, constitutes a sizable and distributed sink capable of storing large quantities of $CO_2$.**

| Supply Chain | Description |
|---|---|
| **Sourcing $CO_2$** | • Coordinating supply chains for the right quantities of the right quality at the right time.<br>• Ensuring regulatory permits are in place for transporting the compressed $CO_2$. |
| **Sourcing mineral feedstock** | • Planning logistics to ensure the most optimal conditions of the mineral feedstocks.<br>• Transport feedstock minerals with bulk trucking or conveyors. |

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|---|---|
| **Processing and quality control** | • Ensuring feedstock meets specific standards regarding porosity, density, and moisture content.<br>• Performing careful quality control and testing to meet regulatory and safety standards feedstock material.<br>• Storing carbonated mineral outputs for integration with building materials. |
| **Manufacturing building materials** | • Integrating supply chains and managing inventory for different $CO_2$-based products.<br>• Performing careful quality control and testing to meet regulatory and safety standards for the final building product. |
| **Transportation to distribution centers** | • Packaging carbonated blocks, panels, or aggregates to protect them from the elements during transport.<br>• Optimizing transportation routes and modes to minimize carbon emissions.<br>• Ensuring accurate documentation to customs authorities if sourced internationally. |
| **Distribution to retailers or construction projects** | • Synchronizing logistics with construction schedules with just-in-time delivery or bulk delivery to project sites.<br>• Aligning production schedules with project timelines between supplier, manufacturer, and construction teams. |
| **Installation and construction** | • Ensuring timely delivery of construction materials to the construction site.<br>• Planning workflows and coordinate to integrate carbonated materials with conventional materials.<br>• Minimizing waste during the construction process. |
| **End-of-life management** | • Planning post-use life, destruction and reverse logistics for carbonated materials.<br>• Enabling building disassembly rather than demolishing to facilitate material recovery and reuse.<br>• Monitoring and reporting the carbon footprint reduction achieved by using the carbonated materials. |

## Logistics challenges

- There is a supply/demand volume mismatch. Most capture projects generate (fossil) $CO_2$ volumes that most utilization solutions cannot fully absorb.
- Securing consistent, high-quality industrial byproduct feedstocks is complicated and often hampered by counterproductive local laws on waste management.
- Materials, industrial byproducts and the $CO_2$ generally come in intermittent flows, requiring extensive logistics services involving many different stakeholders.

## Specific municipal support

- Simplify and speed-up permitting timelines and regulatory approvals for new facilities.
- Enable field trials and create pathways for municipal procurement.
- Establish a collaboration platform to match-make $CO_2$ suppliers, waste material processors, construction product manufacturers, and project developers.