Dramatically reducing embodied carbon

in Europe's built environment

CNCA
CARBON NEUTRAL CITIES ALLIANCE

Laudes Foundation

Dramatically reducing embodied carbon in Europe's built environment

The following tables have been developed under the framework of the project "Dramatically Reducing Embodied Carbon in Europe's Built Environment", launched by Carbon Neutral Cities Alliance (CNCA) in 2021 with the support of the Laudes Foundation.

The suggested recommendations result from the technical assessments conducted by One Click LCA throughout 2021/2022 of leading European cities' current laws impacting embodied carbon and bio-based materials and their possible policy paths and actions forward.

The project involves more than 10 European cities and builds on CNCA Embodied Carbon City Policy Framework, published in 2020.

Recommendations

- Zoning and land use
- Building regulation and supervision
- Procurement
- Waste and circularity
- Municipal buildings
- Urban design guidelines

Zoning and land use

covers policies on what can be built where and land sales / leases. Zoning and land use policies are a key instrument for embodied carbon reduction across the entire construction sector.

Z POLICIES

- Z1 Embodied carbon targets for zoning process
- Z2 Set zoning requirements for bio-based materials
- Z3 Carbon-scored land sales competitions
- Z4 Parking requirement optimization
- Z5 Apartment size and space efficiency guidelines
- Z6 Prefabricated or modular construction priority
- Z7 Increasing density using existing infrastructure
- Z8 Use low carbon building typologies in zoning
- OTHER Avoidance of piling construction sites during the zoning phase where possible

Recommendation issued

Z2 Set zoning requirements for bio-based materials

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Embodied carbon and bio-based materials in strategic plans and policies Due to the future role of climate change and life-cycle emission reductions in the construction sector, the city should also enhance the assessment of all construction related emissions, including material usage along with energy usage into the scope of emissions measured and tracked. The city should also encourage the usage of biobased materials, such as timber, in all construction as well as include biobased materials into urban design guidelines and zoning requirements.		
Embodied carbon and bio-based materials in tendering process Emphasis of embodied carbon and biobased materials in the tendering criteria alongside environmental aspects for all competitions. The usage of biobased materials in constructions, when technically plausible, should be considered in the sub criteria along with emissions from the whole life cycle of materials. Alternatively, the city could set a requirement for the minimum share of biobased materials in new construction. All biobased materials used should be sustainably sourced.		Z3 Carbon-scored land sales competitions
Use of wood in construction Requiring bio-based materials through zoning (either by requiring sustainable wood in the façade and frame, or by adding a minimum requirement for bio-based products).		

Z3 Carbon-scored land sales competitions

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Land use and transfer Even if the city does not include a carbon footprint-based tender criterion in all its plot assignment conditions, a requirement for new plot assignments or plot leases may initially require a carbon footprint calculation and reporting method as described above when applying for a building permit.		Z1 Embodied carbon targets for zoning process
Terms and conditions of land transfer Include the life cycle carbon footprint of all new land transfers in the housing and land policy program as land transfer principles.		M3 Use carbon as a criterion for design competitions
Biobased materials in standard construction requirements Emphasis of role of biobased materials in the city's Standard Construction Requirements - already considering sustainability and embodied carbon in material selection. This can be done either by requiring sustainable wood in the façade and frame, or by adding a minimum requirement for bio-based materials in new construction). All biobased materials used should be sustainably sourced.		

Z3 Carbon-scored land sales competitions

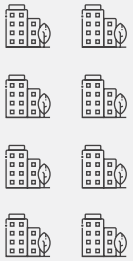
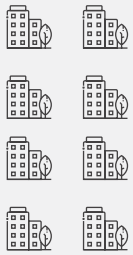
RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Biobased materials in land sales and competitions The city should encourage the use of biobased materials, such as sustainably harvested timber, in chosen land use competitions. This can be implemented so that scoring is based on the primary frame material being for example timber. All timber used must be from 100% sustainable sources.		Z2 Set zoning requirements for bio-based materials
Land use and allocation The city should include life-cycle analysis as a part of the quality criteria in distributing land and require early phase analysis and reporting as a part of land sales. Incorporating the whole life-cycle approach into land allocation would steer new building stock towards more efficient emission reductions. The assessment should be done according to the EN 15978 standard.		R9 Life-cycle carbon calculation and reporting Z1 Embodied carbon targets for zoning process
Climate neutral construction in private The city's plan for climate neutral construction and civil engineering works is targeted predominantly for municipal sector. Where the national legislation limits the city from posing certain requirements above the national ambition, the city can control embodied carbon emissions from private actors by implementing similar requirements into land sales conditions and tenders.		

Z4 Parking requirement optimization

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
City-level parking norms Considering a market-based mechanism for parking place requirements, or enabling deviations from minimum parking place requirements, in sites where priority public transport is available.		
Flexibility of conversion Adding flexibility of conversion when constructing parking spaces, so that in the event of future changes in parking needs, the parking spaces or the area zoned for them can be used for other purposes.		Z1 Embodied carbon targets for zoning process

Zoning and land use | Building regulation and supervision | Procurement | Waste and circularity | Municipal buildings | Urban design guidelines

Z7 Increasing density using existing infrastructure

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Incentives for complementary construction Complementary construction plays an important role in reducing carbon emissions and therefore it is important to direct the volume of construction to the supplementary construction areas. Cities can direct construction to additional construction areas by increasing the permitted construction density in situations where the plot is within the distance defined by the city from the primary public transport service network. An increase in the frequency of renovation must be achievable without the demolition of existing buildings, and extensions granted must not be subject to an extension of the minimum parking area requirements.		
Extension permit for low-carbon projects Added density can often be seen as a considerable financial benefit for many developers. Applying a density bonus for low-carbon projects can allow the city to offer a meaningful incentive resulting in a wider adoption of low-carbon building practices. All new projects that demonstrate embodied carbon reductions and meet the requirements should be eligible for increases in density above the established limit to build more floors compared to the agreed limit. The demonstration of carbon reductions should include a possibility of independent audit by the city officials. The density bonus can also be beneficial to promote building inside existing infrastructure in certain zones.		R4 Density bonus for carbon efficiency

Zoning and land use | Building regulation and supervision | Procurement | Waste and circularity | Municipal buildings | Urban design guidelines

	RECOMMENDED ACTION	CITIES
OTHER	Avoidance of piling construction sites during the zoning phase where possible	
	Driving the volume of new construction to existing infrastructure by facilitating the permit process	

Building regulation and supervision

policies exert influence over all private and public construction, making these policies effective carbon reduction instruments.

R POLICIES

- R1 Life-cycle carbon limits for new buildings
- R2 Low carbon cement and concrete policy
- R3 Material-efficient structural design requirement
- R4 Density bonus for carbon efficiency
- R5 Zero carbon construction sites
- R6 Construction materials efficiency declaration
- R7 Expedited permitting for low carbon projects
- R8 Prohibiting extremely high emitting materials
- R9 Life-cycle carbon calculation and reporting

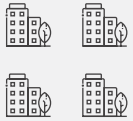
Recommendation issued

R1 Life-cycle carbon limits for new buildings

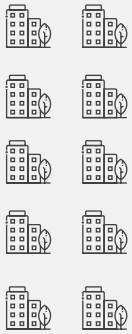
RECOMMENDED ACTION	CITIES	INTERLINKED POLICY

Embodied carbon limits for zoning

Cities should set limits on the maximum embodied carbon for the zoning process. This entails setting a limit on the maximum life-cycle carbon that new buildings can emit during their lifetime, not including operational carbon. The limits shall decrease gradually for building life-cycle emissions. These targets would ensure that investors and developers would use the established targets in their design briefs already on the early stages and designers would work towards achieving limits set.



R2 Low carbon cement and concrete policy

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Require assessment of the profitability and feasibility of low-carbon concrete in building components where the use of concrete is mandatory Low-carbon concrete must be able to reduce the carbon footprint of concrete by at least 30% of the average equivalent product in applications where no particularly demanding technical properties are required. In structures where it is mandatory to use concrete, the usage of low-carbon concrete with a higher share of recycled binders in cement should be considered.		
Building design and construction practices for balconies and kiosks Assessing different material options as to their embodied carbon and prioritizing bio-based materials whenever possible, especially in light weight structures and constructions that are not used year-round or that are only temporary, such as kiosks.		R9 Life-cycle carbon calculation and reporting

R3 Material-efficient structural design requirement

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Material efficiency and sustainability in housing investment plan Including sustainable use of materials, including enhancing the usage of biobased materials and material efficient structural design into housing investment priorities in all projects procured by the city.		

R4 Density bonus for carbon efficiency

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Carbon requirements for land leasing For driving and managing emission, the city should use the following requirement in land leasing contract decisions: • Driving new construction into existing areas and offering a higher residential density incentive to construction that is planned in proximity of priority public transport service. • Calculating the building life-cycle emissions in all projects.		R9 Life-cycle carbon calculation and reporting
Control of private new construction Increasing the permitted building density in many markets is a significant economic benefit for developers. Offering an increase in construction density could be used as a financial incentive for projects that fall short of the required materials carbon footprint target.		

R5 Zero carbon construction sites

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Construction practices Using renewable energy and low carbon fuels in all construction sites alongside existing regulations for a healthy, safe and environmentally friendly construction.		
Emission free sites In addition to giving priority to the site's energy emissions, the city should also include the reduction of material waste and the efficient recycling of reusable materials in the site guidelines. Both the Green Deal and the reduction of material losses should be included in the land transfer conditions.		
Climate neutral construction sites The city has created a plan for climate neutral construction and civil engineering works. The city should consider adding the following specifications and targets into the municipal agenda: • Including replacements (B4) and end-of-life (C1-C4) immediately into reporting scope. • All materials to be designed for disassembly as well longevity in service life. • Considering waste as a part of climate-neutral construction site along with energy emissions from construction site machinery.		R9 Life-cycle carbon calculation and reporting P9 Circular materials purchasing strategy

R9 Life-cycle carbon calculation and reporting

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY

Life-cycle impacts from renovations

To be able to understand renovations and their impact to embodied carbon emissions, it would be crucial to extend life-cycle assessment and embodied carbon assessments into renovations as well. In all city owned projects, cities should assess the whole life-cycle emissions from the renovations. The calculations should be done similarly than life-cycle assessments for new constructions. The assessments should be based on BS EN 15978 standard. On top of this, cities shall also consider the impacts from operational energy (B6) as per BS EN 15978.

Life-cycle based assessment into city's own projects

The calculations should be done based on the EN 15978 standard and would take into consideration at least the following phases:

- A1-A5 according to Klimatdeklaration
- B4 Replacements
- Operational energy (B6)
- C1-C4 End-of-life

Consider carbon footprint of construction in city's housing strategy

This action should consider design for future adaptability, prioritizing usage of biobased materials, and accounting for the carbon footprint of projects, requiring reduction measures to be proposed by designers. This should happen for all projects procured by the city, all new built construction rented on a long term by the city, and all projects financed and constructed by the city.

R9 Life-cycle carbon calculation and reporting

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Incorporate life cycle's carbon footprint to urban strategy Taking into account emissions during the entire life cycle of a building, such as the carbon footprint of materials, and not only energy emissions during the use of buildings, and recognize the importance of the different stages of the procurement process to reduce life cycle emissions in its own projects.		Z1 Embodied carbon targets for zoning process R1 Life cycle carbon limits for new buildings M2 Embodied carbon limits
Understanding embodied carbon emissions created by construction in the city A review on where the city stands in its embodied carbon emissions.		
Project feedback for utilization Feedback information on completed projects is important for assessing current emission levels, as well as for creating good practice. In order to utilize the feedback, the city should document the existing information after the projects are completed.		

Procurement

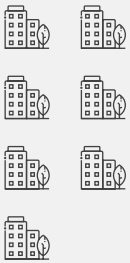
policies allow for leveraging the use of taxpayer money towards embodied carbon reduction.

P POLICIES

- **P1** Carbon limits for key building materials for city projects
- **P2** Green public procurement for public buildings
- **P3** Requirement of recycled aggregates
- **P4** Low-carbon asphalt procurement
- **P5** Require use of certified wood products
- **P6** Circular materials purchasing strategy

Recommendation issued

P1 Carbon limits for key building materials for city projects

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
EPDs in public works and procurement EN 15804 / ISO 21930 compliant Environmental product declarations demonstrate the environmental performance of building products. Where sustainability and circularity are considered in cities' documents, requiring third party verified EPDs should be separately noted. Cities should require the following for public procurement, when possible, by governmental regulation: • For all main building materials, projects shall require suppliers to provide company specific Environmental Product Declarations (EPD) in compliance with EN 15804 / ISO 21930 and ISO 14025. • The EPDs used must be valid at point of specification and cover the products supplied. Product embodied carbon performance data, including EPDs, shall be recorded and submitted as part of the project documentation. Product embodied carbon performance data, including EPDs, shall be recorded and submitted as part of the project documentation.		P2 Green public procurement for public buildings
Third party verified EPD For comparability and reliability of environmental performance, the city should require EPDs used to have a third-party verification, and not only internal verification by the city. EPDs should also be in compliance with EN 15804 / ISO 21930.		

P6 Circular materials purchasing strategy

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY

Circularity in procurement

The city emphasizes circularity and material longevity as a part of its strategy for climate neutral construction. The city should thus implement a detailed strategy to develop procurement in a way where circularity, material efficiency and maintainability are maximized.

The city should ensure that all construction materials ordered for public works that have a minimum service life defined and that can be subject to maintenance, have a maintenance and repair strategy defined, as well as a disassembly or reuse strategy.

Waste and circularity

policies leverage a city's power to regulate permits and therefore attach requirements on waste handling to different types of projects.

W POLICIES

W1	Design for disassembly and adaptability criteria	✓
W2	Mandatory pre-demolition audits and data sharing	✓
W3	Mandatory material takeback program	✓
W4	Soil coordination for mass storage and reuse	✓
W5	Information on adaptability and waste reduction	✓
W6	Materials longevity policy	
W7	Establish or supported materials reuse facilities	
W8	Carbon or salvaging requirement for demolitions	
W9	Mandatory construction and demolition waste landfill diversion	
OTHER	Reusing carbon intensive elements (such as foundations) in demolition – new construction projects	✓

✓ Recommendation issued

W1 Design for disassembly and adaptability criteria

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Urban design guidelines and embodied carbon Alongside the existing emphasis on the durability and adaptability of construction materials, urban design guidelines should indicate that a design for disassembly strategy should be conducted so that reusable materials can be disassembled in a manner that allows their efficient reuse.		R2 Low carbon cement and concrete policy
Circular economy and material disassembly In connection with the transfer of land, the city should require that the demolition of specified materials and components be taken into account in connection with the Design for Disassembly principle.		

Zoning and land use | Building regulation and supervision | Procurement | **Waste and circularity** | Municipal buildings | Urban design guidelines

W2 Mandatory pre-demolition audits and data sharing

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Renovation and deconstruction permit In terms of demolition, the city should encourage for pre-demolition audit to ensure the recovery of recyclable.		**W5** Information on adaptability and waste reduction **M6** Renovation vs. knock down and rebuild comparison
Service and annual plan of the housing and real estate board If dismantled sites in the service network are dismantled, a dismantling strategy should be identified for these sites. Information on demolition and materials should be made public to allow more efficient reuse and recycling of materials left in the building.		

W3 Mandatory material takeback program

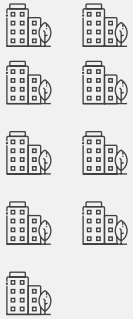
RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Utilization of surplus material Providing efficient and cost-effective guidance in construction sites on the re-use of reusable materials that still bear the CE marking. Preparing a Green Deal that adds guidelines for the reduction of material waste and the efficient recycling of reusable material. Both guidances should be included in the terms of the land transfer.		R5 Zero carbon construction sites
Waste management and surplus material The usage of street space to hold interchangeable containers should be made easier in cases where the container has been ordered in order to re-commercialize surplus materials. As an alternative to this, new construction, refurbishment or renovation projects could include a designation of a waste management supplier and a separate trader of surplus building materials, with their name and telephone number.		R5 Zero carbon construction sites

W4 Soil coordination for mass storage and reuse

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY

Mass flow coordination

Excavation, transport and compacting of masses requires a significant amount of fuel and causes carbon. Coordinating mass flows can reduce transport and increase reuse of excavated waste masses for new buildings, and help the demand meet supply. It also avoids disposing of soils, as both supply and demand for soil have matchmaking. This requires maintaining an inventory of soils and forecasting supply and demand.



W5 Information on adaptability and waste reduction

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Discharge effects and discharge permit Extending the life cycle of buildings that can be repaired instead of being demolished. For this, it will be important that emissions from life-cycle extensions are assessed and compared with demolition and reconstruction emissions. In all demolition projects that are intended to be rebuilt in place of the demolished site, the city should request a report on the emission effects of demolition and rebuilding in connection with the demolition permit, and compare these with the lifetime emissions.		M6 Renovation vs. knock down and rebuild comparison

OTHER	CITIES
Reusing carbon intensive elements (such as foundations) in demolition – new construction projects	

Municipal buildings

policies specifically target buildings that are owned and/or operated by the city, which typically account for a small percentage of total citywide building stock.

M POLICIES

- M1 Space use and occupancy efficiency
- M2 Embodied carbon limits for new & leased buildings ✓
- M3 Use carbon as a criterion for design competitions ✓
- M4 Low carbon sites, stabilization and foundations ✓
- M5 Publicize best practices and case study projects
- M6 Renovation vs. knock down and rebuild comparison ✓
- M7 Salvaged, reused or recycled material minimums

✓ Recommendation issued

- OTHER Action plan for embodied carbon ✓

M2 Embodied carbon limits for new & leased buildings

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Embodied carbon review In addition to the carbon footprint of energy consumption metrics used for the construction sector and its emissions in the city, the following metrics should be added: Embodied carbon from city owned new construction and renovation projects and yearly reductions in embodied carbon along with energy emissions.		
Limit values in the city's own projects The limit values to be developed should take into account lifecycle emissions, including the emission effects of replacements and dismantling. The emission targets of its own projects should be tied either to national limit values, or to the development of limit values for building types that are stricter than the national values, utilizing feedback and emission data from the city's own projects.		R1 Set life cycle carbon limits for new buildings

M3 Use carbon as a criterion for design competitions

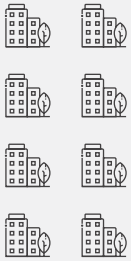
RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Construction practices Setting targets and encouraging an easier usage of existing non-used materials that are left over from the construction site. This can be for example done by collecting materials that are untouched and still have a standing CE marking from the building site and selling them forward to usage on other sites.		
Plot transfer Taking into account emissions from building materials in all land transfers and new lease agreements. More specific requirements, such as sanctions, can be agreed separately in the projects. Materials to be returned: • Carbon Footprint Report. • Resources used in the calculation and their quantities. • More specific requirements may be proposed separately for projects, such as third party verification of results. Notes on calculation: • Calculation assumptions: If the assumptions made in the calculation differ from the scenarios proposed by the Ministry of the Environment, the deviation must be presented in the report in a justified and data-based manner.		Z3 Carbon-scored land sales competitions

Zoning and land use | Building regulation and supervision | Procurement | Waste and circularity | **Municipal buildings** | Urban design guidelines

M3 Use carbon as a criterion for design competitions

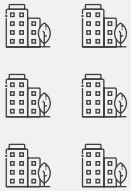
RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Carbon footprint in city competitions Incorporating a carbon footprint into the evaluation of tenders will make it possible to find low-carbon solutions in a cost-effective way and bring out potentially innovative proposals in which the carbon footprint is included in the design process right from the start of the project. In competitions where the carbon footprint is one of the scoring criteria, competitors often seek to optimize material consumption efficiently, as well as to seek lower-emission materials and energy-efficient solutions in order for a competition proposal to be accepted. In order for competition to allow equal opportunities for all and guarantee the best possible outcome, not only from a computational point of view, but also in the real world, it is important that the rules of competition are as unambiguous as possible in terms of carbon footprint. **Proposal for the requirements has also been provided.*		Z3 **Carbon-scored land sales competitions**

M4 Low carbon sites, stabilization and foundations

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Zoning priority on constructible soils Before zoning the area for construction, the soil should be examined. Cities should prioritize for construction areas that are more favorable with good soil and lower embodied carbon impacts. Before zoning, every project shall be evaluated for soil type. Construction in areas that emit significantly higher emissions due to their soils should, in principle, be avoided in construction. Especially if a possible reduction in operational and/or transport emissions do not counterbalance the effects of the soil quality on life-cycle emissions. All construction and zoning requirements related to large amount of underground parking for example should be avoided		Z1 Embodied carbon targets for zoning process
Soil analysis and avoidance of poor soils in new construction Before the site for a new project is chosen, the carbon impacts resulting from the soil type and depth should be analyzed. The specific location of the building on the plot should consider underground context, and the actual implementation of the stabilization as well as foundations needs to be designed and executed considering carbon.		

Zoning and land use | Building regulation and supervision | Procurement | Waste and circularity | **Municipal buildings** | Urban design guidelines

M6 Renovation vs. knock down and rebuild comparison

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Demolition versus refurbishment assessment Refurbishing and potentially expanding an old building, instead of demolishing and building anew, should be considered. Cities should in city projects assess and compare the emissions from both alternatives. In all city owned demolition projects, where the intention is to demolish and build a new building, the city should conduct a life-cycle assessment for both cases: demolitions and new construction, and refurbishing/extension, and demonstrate that the proposed option has a lower climate impact.		**W2** Mandatory pre-demolition audits and data sharing **W5** Information on adaptability and waste reduction

OTHER

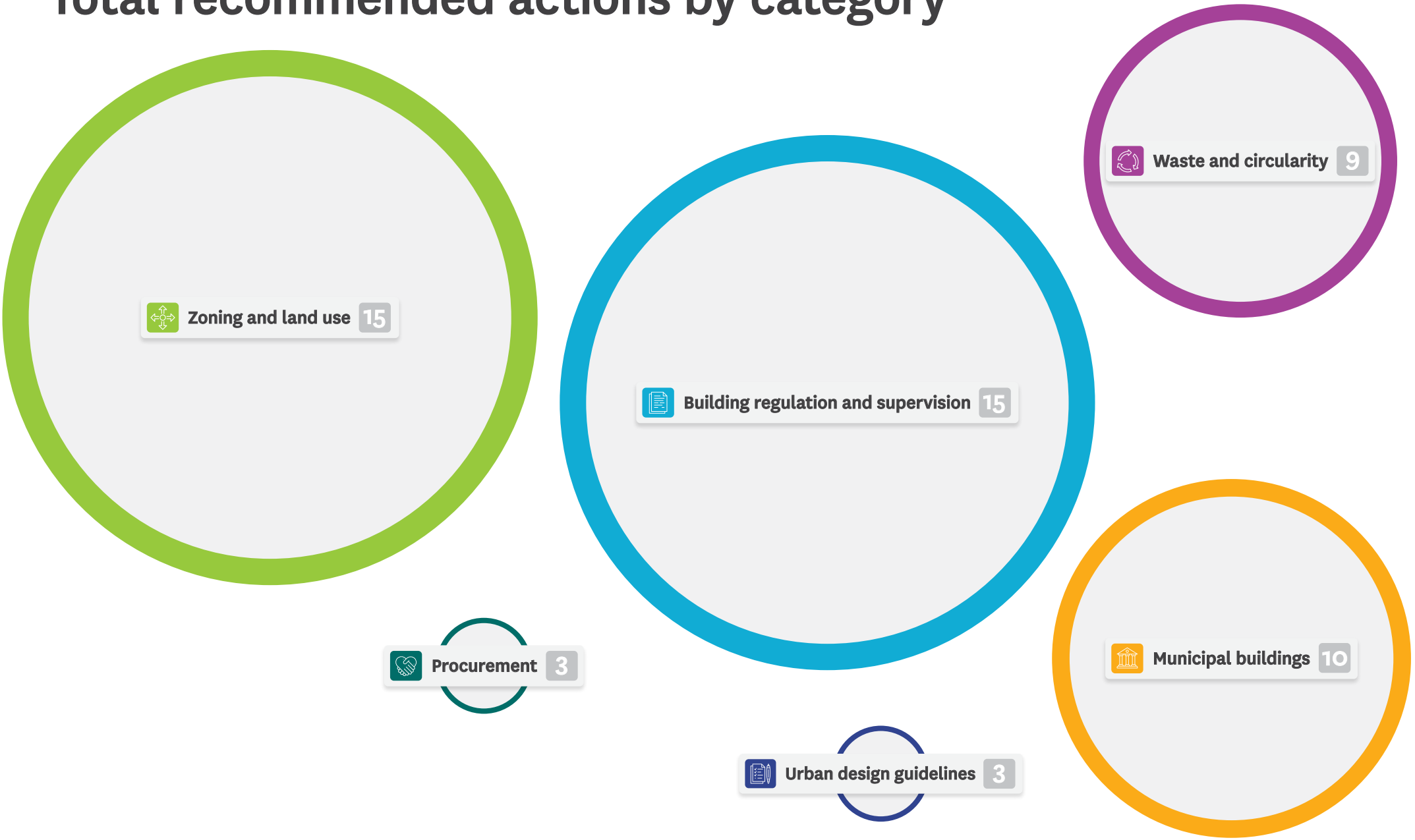
Action plan for embodied carbon

RECOMMENDED ACTION	CITIES	INTERLINKED POLICY
Promoting and increasing the share of biobased materials, such as sustainably procured timber, in all city-owned construction		
Directing wood construction in the organization		

Urban design guidelines

RECOMMENDED ACTION	CITIES
Updating urban space guidelines to include a carbon footprint calculator for urban furniture	
Urban landscape design to promote the usage of biobased materials in suitable designs whenever technically and aesthetically possible	
From Puccini method to sustainability and circularity to promote the usage of products that have lower life-cycle emissions and materials with a higher recycled content	

Total recommended actions by category



Top 10 recommended actions

10 cities	R2	Require assessment of the profitability and feasibility of low-carbon concrete in building components where the use of concrete is mandatory
9 cities	W4	Mass flows coordination
8 cities	M4	Zoning priority on constructible soils
8 cities	Z7	Incentives for complementary construction
7 cities	P1	EPDs in public works and procurement
6 cities	M6	Demolition versus refurbishment assessment
6 cities	W4	Reusing carbon intensive elements (such as foundations) in demolition – new construction projects
6 cities	Z7	Extension permit for low-carbon projects
5 cities	R9	Life-cycle based assessment into city's own projects
4 cities	W3	Waste management and surplus material

Dramatically reducing embodied carbon

in Europe's built environment

About the developers of this report

Carbon Neutral Cities Alliance is a collaboration of leading global cities working to achieve carbon neutrality by 2050 or sooner — the most aggressive GHG reduction targets undertaken anywhere by any city.

For more information: www.carbonneutralcities.org.

One Click LCA is a firm of construction carbon specialists operating globally out of Finland. One Click LCA works with construction carbon regulations, research and standardization. Bionova is also the developer of the world-leading construction life-cycle assessment software One Click LCA.

For more information: www.oneclicklca.com/about-bionova-ltd/.

For any questions, reach out to:

Irene Garcia
CNCA Embodied Carbon Project Manager
irenegarcia@carbonneutralcities.org

June 2022

CNCA
CARBON NEUTRAL CITIES ALLIANCE

Laudes Foundation