CNCA
CARBON NEUTRAL CITIES ALLIANCE

One Click LCA

CITY POLICY FRAMEWORK FOR

DRAMATICALLY REDUCING EMBODIED CARBON

52 detailed policies to reduce embodied carbon

embodiedcarbonpolicies.com

DEVELOPED BY

CNCA
CARBON NEUTRAL CITIES ALLIANCE

One Click LCA

IN COOPERATION WITH

architecture 2030

WITH SUPPORT FROM

Rockefeller Brothers Fund
Philanthropy for an Interdependent World

CONSTRUCTION CLIMATE CHALLENGE™

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

Canada

Oslo

CITY OF TAMPERE

Helsinki

ENDORSEMENTS

“One billion new homes need to be built in cities around the world by 2025. There will be twice as many buildings on earth by 2050 than there are today. Without low-carbon clean construction, those buildings are going to lock-in huge amounts of greenhouse gas emissions and accelerate the climate crisis. Fortunately, mayors of the world's great cities are embracing clean construction. This framework, combined with C40 's Clean Construction Policy Explorer, will help cities deliver on their commitment to climate action and a sustainable future for all.”
Kevin Austin, Deputy Executive Director, C40 Cities

"Delivering a net zero carbon built environment is one of the most critical challenges of our times. This excellent report shines a light on how policy makers can ensure they are addressing the whole carbon picture - and moving towards our vision of net zero embodied carbon by 2050."
Cristina Gamboa, CEO, World Green Building Council

"Authentic climate action requires cities to rapidly scale up the development of Zero Carbon buildings that neutralize embodied carbon. This indispensable framework offers policymakers a clear pathway and a comprehensive array of policies to accelerate this effort to decarbonize the built environment."
Andrew Lee, Director of Energy + Carbon, International Living Future Institute

“This report sends a strong signal to materials manufacturers and construction companies that global cities are poised to demand low and zero carbon building solutions, and that their demand will grow rapidly. Cities are collectively the number one change agent when it comes to tackling embodied carbon. This report lays out clear market pathways and policy frameworks for cities and companies to align around as they plan for how to decarbonize their cities and businesses.”
Margaret Hansbrough, Director, Mighty Earth

FOREWORD

This policy framework is intended for cities and other government bodies to develop a strategy, action plan and policies they can adopt to dramatically reduce embodied carbon, defined as carbon emissions from manufacture, transport, use and end of life of construction materials. This is a manual and a blueprint for cities and government bodies to respond to the climate emergency. This report is for cities who understand that reducing and eliminating embodied carbon is critical to their climate objectives, and wish to understand what they can do, how to do it, and what the most carbon-reducing, cost-effective, easiest-to-implement, and enforceable policies are that could be adopted to spur and accelerate the transformation to low carbon construction.

This report contains 52 policies cities can adopt to reduce embodied carbon. It collects best practises, mostly from cities in Europe and North America, and introduces new policies, not yet implemented anywhere in the world. The policies listed are most applicable for Europe and North America, and may need adaptation for other regions. All listed policies are evaluated for their impact. This research specifically concerns embodied carbon. Policies for other industries or processes are not considered.

The project delivering this report was coordinated by the Carbon Neutral Cities Alliance, and a steering group composed of the following world-leading cities: Copenhagen, Helsinki, Oslo, San Francisco, Seattle, Vancouver, London, Boulder, New York, Tampere, and Portland.

This report has been authored and edited by Bionova Ltd (better known under its One Click LCA brand), with contribution from Architecture 2030. The project was made possible by the generosity of following funders: Rockefeller Brothers Fund, Ministry of Environment of Finland, National Research Council of Canada, Construction Climate Challenge hosted by Volvo Construction Equipment, and cities of Oslo, Helsinki and Tampere.

The lead author was Panu Pasanen. Contributors from Bionova Ltd were Johanna Jarvinen, Kostas Koukoulopoulos, Lorélia Le Gouvello, Tytti Bruce, Rodrigo Castro, Fernando Barrios and Johanna Parisi. Contributors from Architecture 2030 were Erin McDade, Natasha Balwit and Vincent Martinez. Special thanks go to John Orr of the University of Cambridge, Donald Davies of Magnusson Klemencic Associates, Cécile Faraud and the clean construction team at C40 cities and Tomi Lehtinen of Netlet Oy.

For cities looking for a way to start working with embodied carbon in practise, a free to use embodied carbon and construction materials efficiency software One Click LCA Planetary was launched by the report editors, and it may be used as a resource.

Any errors or omissions in the report are the authors', and if you spot any, we'd like to hear from you at hello@bionova.fi.

1. WHY CITIES MUST ACT AND THE CHANGE THAT IS REQUIRED

1.1 WHY CITIES MUST ACT ON EMBODIED CARBON NOW

According to the C40 Cities, cities account for more than 70% of global CO2 emissions already today. UN Population Division estimates that cities add 2,75 billion residents by 2060, absorbing the entire global population growth projected for that timeframe. The global new construction projected to accompany that population growth is equal to building one New York City each and every month for the next 40 years.

According to the International Energy Agency, buildings and construction are responsible for 39 % of carbon emissions already today. Embodied carbon contributes about 11 % of all global carbon emissions and as a consequence of urbanization, practically all of it is caused by demand in cities. Unless the construction sector's embodied carbon intensity is drastically cut, embodied carbon from new buildings, renovations and infrastructure until 2060 may exceed 230 gigatons – more than six years of today's global fuel combustion carbon emissions.

World Green Building Council's report "Bringing Embodied Carbon Upfront" sets 2020 as the deadline year for all cities to start developing a strategy to achieve net zero embodied carbon target. The strategy would comprise of embodied carbon reduction targets, mandatory LCA of buildings as well as targets and timelines for low carbon public procurement, with all actions being adopted by 2024. Leading cities will do more, and sooner.

CITIES GROW BY 2,75 BILLION RESIDENTS BY 2060, RESULTING TO OVER 230 GIGATONS OF EMBODIED CARBON

1.2 CHANGE REQUIRED TO DRAMATICALLY REDUCE EMBODIED CARBON

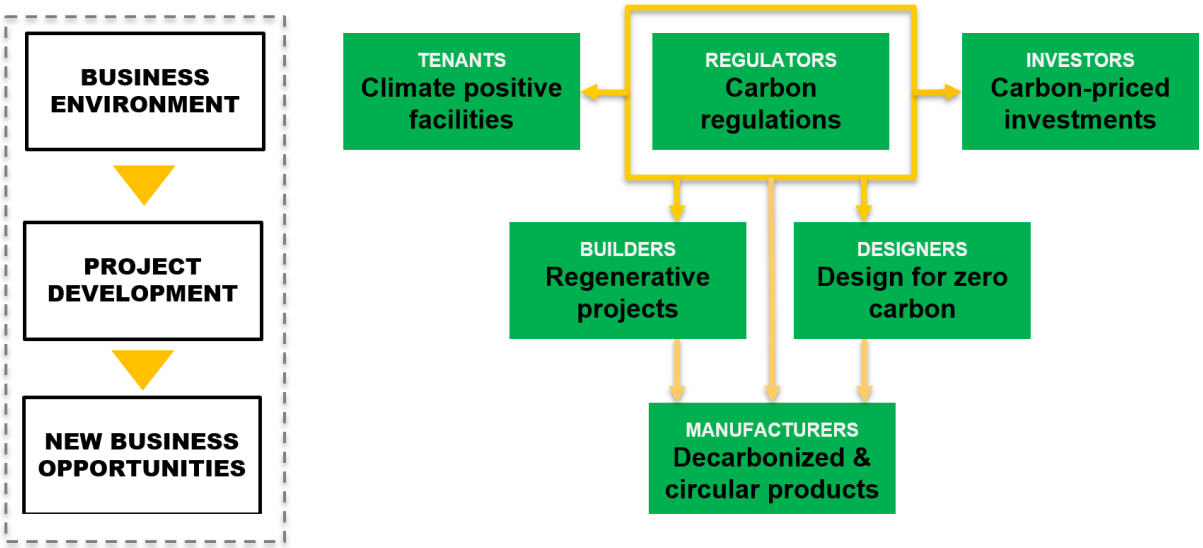
Dramatic reduction of embodied carbon does not only entail a change for the construction trade itself, but also for the whole business environment surrounding the construction trade. It is not enough to reduce carbon from materials: dramatic reduction also requires changes to what we build and where, how requirements for projects are determined, as well as how projects are designed and delivered. It also requires changes to how materials recovery and waste handling operate, as well as how land use is managed and optimized.

Construction is one of the biggest industries and employers globally. As the overall scope of the change is huge and it affects a major industry, it is necessary that all policy starts with actions on the main drivers and focuses on actions relevant for those drivers.

Cities enjoy a linchpin position to implement regulations. Cities can calibrate their policies to be aligned with local capabilities and available solutions, as well as purchasing power, cost of construction and prevailing conditions more closely than national regulators.

The embodied carbon targeting policies are part of the necessary business environment which can bring about a zero-carbon construction sector. The business environment will also require tenants and investors to ask for low or zero carbon projects, which in turn will help cascade requirements down to the project teams and further to product manufacturers. These interactions are visualized in the following figure.

Figure 1 Business environment and requirements to bring about zero carbon construction



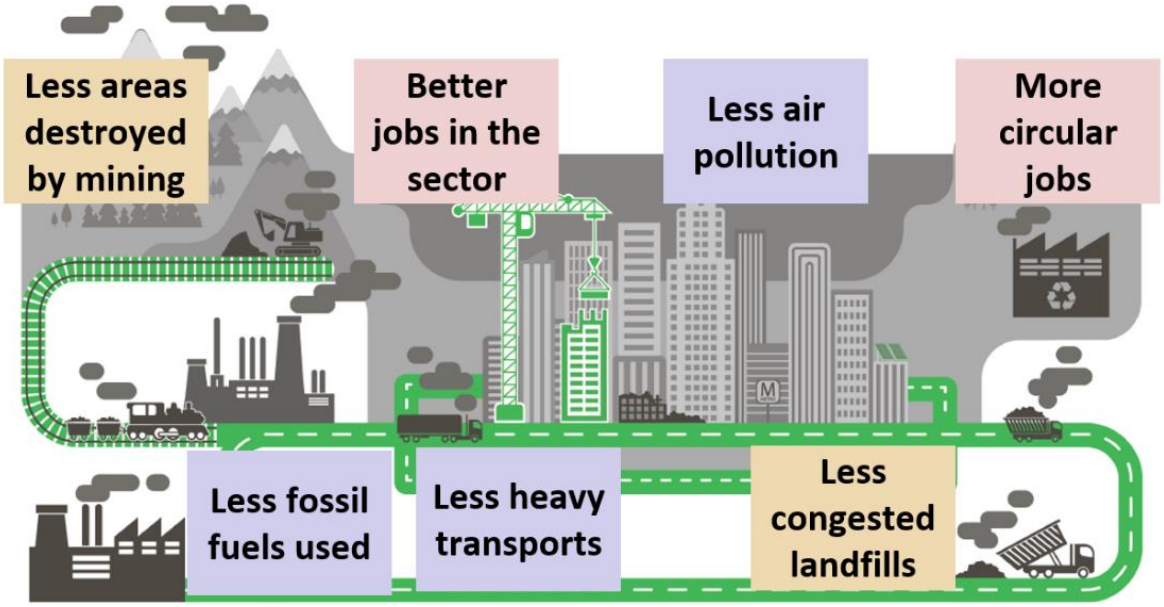
1.3 EMBODIED CARBON REDUCTION BENEFITS TO CITIES

Focusing on embodied carbon supports economic development towards low carbon business models and increases resource efficiency of local businesses, and foster the development of local circular businesses. In addition of supporting economic development, cities also have direct benefits from increasing liveability.

Cities and citizens suffer the local consequences of embodied carbon, including:

- acoustic, particulate and health harming emissions of site machinery and dust;
- acoustic, particulate and health harming emissions of manufacturing;
- congestion, accidents, wear and tear of roads and particulate as well as local health harming emissions resulting of goods and waste transport; and
- loss of natural resources and areas of recreation because of landfills, sites of extraction as well as inefficiently built or used land.

Figure 2 Embodied carbon reduction benefits to communities



EXECUTIVE SUMMARY

Buildings and construction are responsible for 39 % of carbon emissions. Construction materials cause half of raw materials demand in Europe and about 11 % of all global carbon emissions. Construction machinery, transport and construction and waste management increase these emissions further.

Cities account for more than 70% of global carbon emissions already today, and cities are estimated to add 2,75 billion residents by 2060 – nearly absorbing the entire global population growth. This causes unprecedented demand for construction in cities. Consequently, embodied carbon, or carbon from extraction, manufacture, transport, use and end of life of construction materials, is set to grow rapidly in cities. Dramatic embodied carbon reduction action is required to mitigate the climate breakdown.

World Green Building Council has set 2020 as the deadline for cities to start developing a strategy to achieve net zero embodied carbon goals, and to achieve net zero carbon built environment by 2050. This report helps cities to do that by choosing, prioritizing and preparing policies that effectively reduce embodied carbon.

BUILDINGS AND CONSTRUCTION ARE RESPONSIBLE FOR 39 % OF GLOBAL EMISSIONS – MOST OF IT FROM CITIES

The scale of change required is dramatic. It requires changes to what we build and where, how projects are chosen and delivered, and how materials are made, recycled and utilized. Cities enjoy a linchpin position to drive the change. Most cities in Europe and North America enjoy a planning monopoly – being able to choose what can be built and where - and cities can calibrate their policies to be aligned with local capabilities and available solutions, purchasing power, cost of construction, and prevailing conditions more closely and rapidly than national regulators.

Embodied carbon can be reduced by a broad range of measures with varying degrees of impact and ease of implementation. This range can be visualized using the Embodied Carbon Reduction Pyramid (page 16), which outlines five pathways to reduction: 1) redefine the solution, 2) refurbish existing assets, 3) reduce & replace materials and structures, 4) reuse products and materials, and 5) require low carbon products. Policies which fall at the base of the pyramid have the most impact potential but may be harder to implement at scale, whereas policies that fall at the top of the pyramid may be easier to implement but have a lower impact potential. The pyramid can be used to help classify and prioritize policies.

The report provides high-level overview of the legal powers and areas of control and influence for cities in Europe, the United States and Canada. Most legal powers were

found to be broadly comparable in all three regions However, zoning and planning, public procurement, product market access, building codes and mandatory requirements, and clean air and greenhouse gas emissions regulations, were found to differ from region to region. These variations are therefore discussed for each of the three regions separately. Legal powers available in other geographies may vary.

This report documents in detail a set of 52 policies that cities can enact to reduce embodied carbon. Each policy has been evaluated by Bionova experts for potential carbon reduction impact, cost efficiency, ease of implementation and enforceability on a scale from 1 to 5. Evaluations were done on basis of a hypothetical one million inhabitant city with a growing population, and a typical level of skills, services and solutions for cities active within green building.

The 52 embodied carbon reduction policies are grouped into five categories within which cities set policies: Zoning & Land Use, Building Regulations, 3) Procurement, Waste & Circularity, and Financial Policies. An additional two categories group by asset class: Municipal Buildings and Infrastructure. Many of the policies in the report fall into two or more of these categories.

THIS REPORT COVERS 52 POLICIES FOR CITIES TO ENACT TO REDUCE EMBODIED CARBON

1. ZONING AND LAND USE policies are a key instrument for embodied carbon reduction. This report details eight effective policies that can reduce carbon across the entire construction sector, the most impactful of which was determined to be *Embodied Carbon Targets for Zoning Process*. This policy requires all construction with this zoning designation to meet embodied carbon requirements, and constraints zoning in a way to ensure that it will be achieved.

2. BUILDING REGULATIONS/ORDINANCES exert influence over all private and public construction, making these policies effective carbon reduction instruments. This report details nine regulation/ordinance policies, the most impactful of which was determined to be *Life-Cycle Carbon Limits for New Buildings* which defines the maximum carbon impact a new project can have.

3. PUBLIC PROCUREMENT policies allow for leveraging the use of taxpayer money towards embodied carbon reduction. This report details six procurement policies, the most impactful of which was determined to be *Carbon Limits for Building Materials Procurement*. It allows for setting fixed maximum carbon limits for key construction materials, including concrete, steel, bricks, glass, gypsum board and insulation, and requiring all projects completed with city funding to use products meeting those carbon limits. This can also be extended to infrastructure projects.

4. WASTE AND CIRCULARITY policies leverage a city's power to regulate permits and therefore attach requirements on waste handling to different types of projects. This report details nine such policies, the most impactful of which was determined to be *Design for Disassembly and Adaptability Criteria*. This policy ensures that building elements and materials can be recovered via deconstruction and reused, not just recycled.

5. FINANCIAL policies govern taxation, fees and incentives. This report details eight financial policies. One of the most impactful policies in this area was determined to be *Increased Property Tax for Unoccupied Properties*. This policy will only work in cities where speculative investment or other conditions keep many properties unoccupied, but this example highlights the potential for policies not thought of as embodied carbon policies, but which still have a direct and strong link to reducing embodied carbon by limiting unnecessary construction.

6. MUNICIPAL buildings policies specifically target municipal buildings, which typically account for a small percentage of total citywide building stock. This report details seven such policies. One of the most impactful policies in this area was determined to be *Use Carbon as a Criterion for Design Competitions*. This policy enables choosing competition winners using embodied carbon performance as one of the award criteria, thus making it a competitive element.

7. INFRASTRUCTURE development typically covers a significant portion of all city construction, and infrastructure projects use vast amounts of basic materials. In addition to covering built assets, this category also covers green areas such as parks. This report details five infrastructure development policies. The most impactful infrastructure policy was determined to be *Early Design Carbon Targets for Infrastructure*. As most infrastructure projects are different from each other, they require project specific carbon targets to be set.

This report does not issue recommendations for what policies a city should adopt, as this depends on each city's goals, situation and other factors. This report provides a range of options from which cities can identify solutions, which can then be evaluated against city-specific objectives and circumstances.

To help cities to develop skills for and to start developing their own embodied carbon reduction policies, a series of webinars supporting the implementation of this report will be made available at www.embodiedcarbonpolicies.com. Further resources, including C40 Cities Clean Construction Policy Explorer are listed in the chapter 6.3. References are provided at the end of this report.

TABLE OF CONTENTS

GLOSSARY

The following terms are used in this report:

Carbon-dioxide equivalent (or CO_2e), refers to the global warming that is caused by all greenhouse gases released by a specific activity (e.g. concrete manufacturing). In addition to carbon dioxide (CO_2), it includes the impact of other greenhouse gases.

Carbon emissions is shorthand for the emissions of all greenhouse gases, carbon and others.

Construction and Demolition Waste (or CDW) means all waste arising out of the demolition, renovation or construction of buildings.

Embodied carbon refers to the total impact of all the greenhouse gases emitted by the supply chain of a construction material, including raw material extraction, transport to the manufacturing plant, the manufacturing process, the transport of finished goods to the construction site, construction site activities and material losses, materials use phase, repair, maintenance and replacement, as well as the end of life processing.

Environmental Product Declaration (or EPD) is a third-party verified report of Life Cycle Assessment (LCA) results, relating here to a construction product or a material. It uses ISO and often also EN standards. It documents the actual environmental performance of a product.

Green Public Procurement (GPP) means public procurement that uses any form of sustainability criteria either as requirements or as award criteria.

Life Cycle Assessment (or LCA) is a method of assessing the environmental impacts associated to all stages of a product's or building's life, from raw material extraction to its processing, manufacture, distribution, use, repair, maintenance, and end of life treatment.

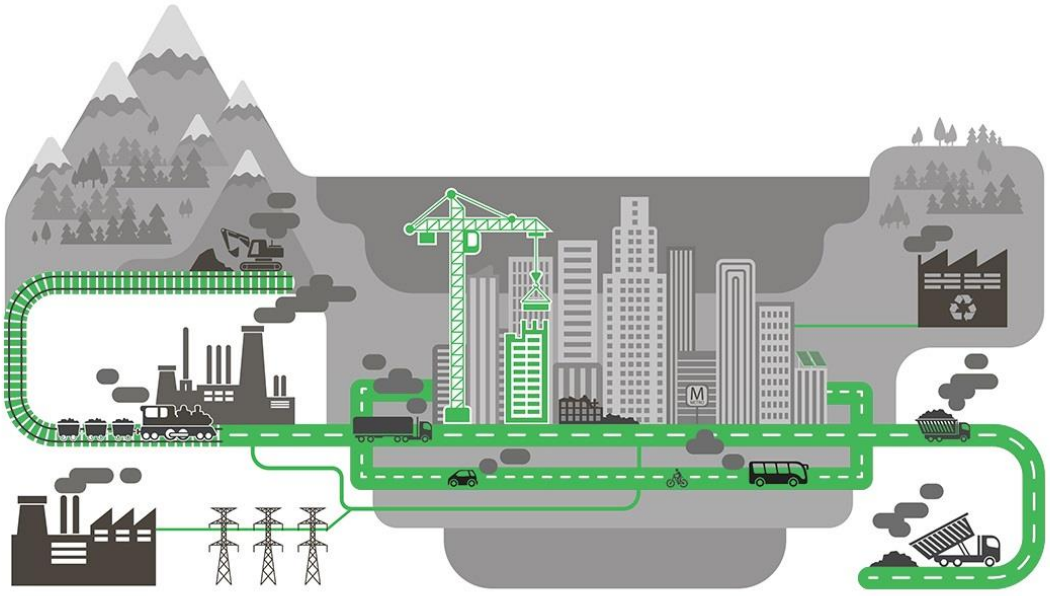
Life Cycle Carbon means the total impacts of all the greenhouses gases emitted for a built asset, including embodied carbon (see above) as well as operational carbon from use of energy and water, over its whole life-cycle from construction through use to end of life.

2. WHAT IS EMBODIED CARBON AND HOW IS IT CALCULATED

2.1 WHAT IS EMBODIED CARBON

In the context of this report, embodied carbon means the total impact of all the greenhouse gases emitted by the construction and materials of our built environment. It includes the impacts of sourcing raw materials, manufacturing, transport, the construction & installation activity and wastage in the process. Further, during their life cycle, the same products also cause carbon impacts when they are maintained, repaired, or disposed of.

Figure 1 embodied carbon emissions arising from material flows of buildings



The standard definition for embodied carbon is in the European Standard EN 15804/ISO 21930. This definition has been summarized in a more easily digestible form by World Green Building Council's definition, which synthesizes the life-cycle stages as follows (letter and number combinations refer to EN 15804 life-cycle stages):

"Embodied carbon: Carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. Embodied carbon therefore includes: material extraction (module A1), transport to manufacturer (A2), manufacturing (A3), transport to site (A4), construction (A5), use phase (B1, e.g. concrete carbonation but excluding operational carbon), maintenance (B2), repair (B3), replacement (B4), refurbishment (B5), deconstruction (C1), transport to end of life facilities (C2), processing (C3), disposal (C4). Benefits beyond the system boundary (D) should also be reported separately to modules A C."

2.2 WHAT CAUSES EMBODIED CARBON AND HOW IS IT CALCULATED

Embodied carbon is caused by carbon from non-renewable energy sources or otherwise being released from natural resources to the atmosphere as a consequence of human activity. Natural processes, for example wildfires, are not considered for these purposes. Embodied carbon is assessed on a life-cycle basis; thus, emissions that arise at all points in the supply chain are considered.

The main sources of embodied carbon emissions, in descending order of impact, are:

- Fossil fuel (e.g. coal, natural gas) incineration in materials manufacturing, and the whole life-cycle extraction emissions for those fuels
- Fossil fuels for supply electricity or other energy for materials manufacturing, and the whole life-cycle extraction emissions for those fuels
- Carbon emissions from chemical reactions in manufacturing of for example cement, aluminium and iron
- Carbon emissions from fossil fuel combustion in transport and site machinery, and the whole life-cycle extraction emissions for those fuels
- Carbon emissions released at the end of life handling of materials, including incineration of plastic based products or wood transforming to methane at landfill
- Carbon emissions released from degradation of forestry and release of soil carbon (often reported separately as land use and land use change emissions)
- Carbon emissions released via leakages of refrigerants

Embodied carbon reduction measures influence above mentioned processes directly or indirectly to achieve emissions reductions within the construction industry. For example, banning landfilling of wood or other biogenic materials, would reduce the release of embodied carbon from the decomposition of the organic matter, as long as the alternative processing methods applied have lower carbon impacts.

Embodied carbon calculation in the construction sector follows European Standards EN 15804 and 15978 and International Standard ISO 21930. These are mutually compatible, and the ISO standard was implemented based on the EN standards. Embodied carbon emissions are calculated typically using life-cycle assessment (LCA) software for designers (as opposed to software for LCA specialists), which take care of the conformity with the required standards while hiding some of the underlying complexity.

Biogenic carbon emissions resulting from the incineration of biogenic materials, such as wood, from sustainably managed forestry are generally calculated as zero emissions, or reported separately. The underlying assumption is that a sustainably managed forestry is able to recover a similar amount of carbon in future growth. This is in line with the industry practise as well as the EN 15804/ISO 21930 standards. Biogenic carbon storage in materials used in construction is generally, as well as according to the latest EN 15804/ISO 21930 standards, calculated separately of the emissions. This way, they are provided as additional information to the party making decisions on the project. Making use of this additional information is up to the users.

3. HOW CITIES CAN REDUCE EMBODIED CARBON

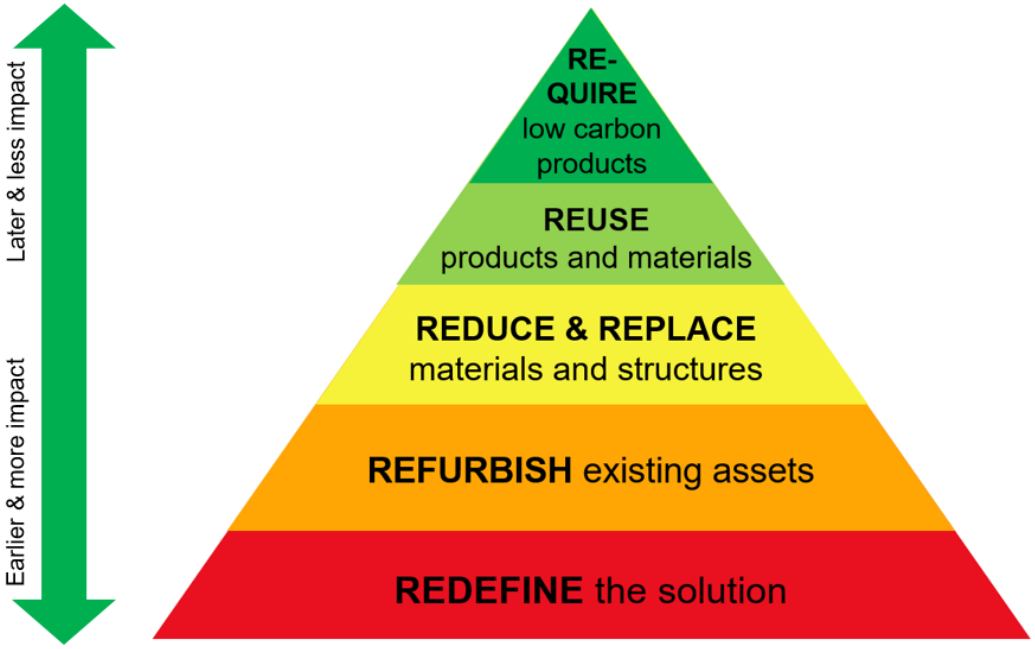
3.1 EMBODIED CARBON REDUCTION MEASURE TYPOLOGIES

Embodied carbon reduction measures can be classified into one of the following typologies. The typologies are organised in this list so that the most impactful measures come last, to match the order of the pyramid visualising them below.

- REQUIRE low carbon products ensures that materials used are low carbon.
- REUSE products and materials at end of life for additional uses for unused products from sites and for salvaged materials from refurbishments and demolitions.
- REDUCE & REPLACE materials and structures reduces the total net use of materials by design and uses lower carbon structures and materials where appropriate.
- REFURBISH existing assets. This reduces total materials use, and can be a powerful decarbonisation strategy, where it does not compromise energy efficiency.
- REDEFINE the solution to address needs by means other than construction, or by implementing measures that have result to net carbon reductions.

Measures at the base of the pyramid have a higher impact than measures at the top. However, implementing measures at the base of pyramid has more constraints than for the measures at the top, which may limit the scale such measures can have. This pyramid follows the structure of Kyoto pyramid for energy efficiency in buildings. Embodied carbon pyramid is aligned with waste and circularity priorities to prioritize preservation of material. This is visualized below.

Figure 2 Embodied Carbon Reduction Pyramid



3.2 EMBODIED CARBON REDUCTION POLICIES AND TARGETED ASSETS

Embodied carbon reductions in city operations can be set in motion by policies. For the purposes of this report, the relevant policies are grouped into the following types:

- ZONING & LAND USE covers policies on what can be built where and land sales / leases.
- REGULATION means here policies affecting also private sector construction.
- PROCUREMENT includes how policies directing what and how materials, projects and services are purchased.
- WASTE & CIRCULARITY covers policies affecting materials life-cycle and end of life use.
- FINANCIAL policies include taxation, fees, incentives and commercial (dis)advantages.
- Policies for INFRASTRUCTURE projects (assumed to be in public ownership).
- Policies for MUNICIPAL BUILDINGS (potentially with broader applicability).

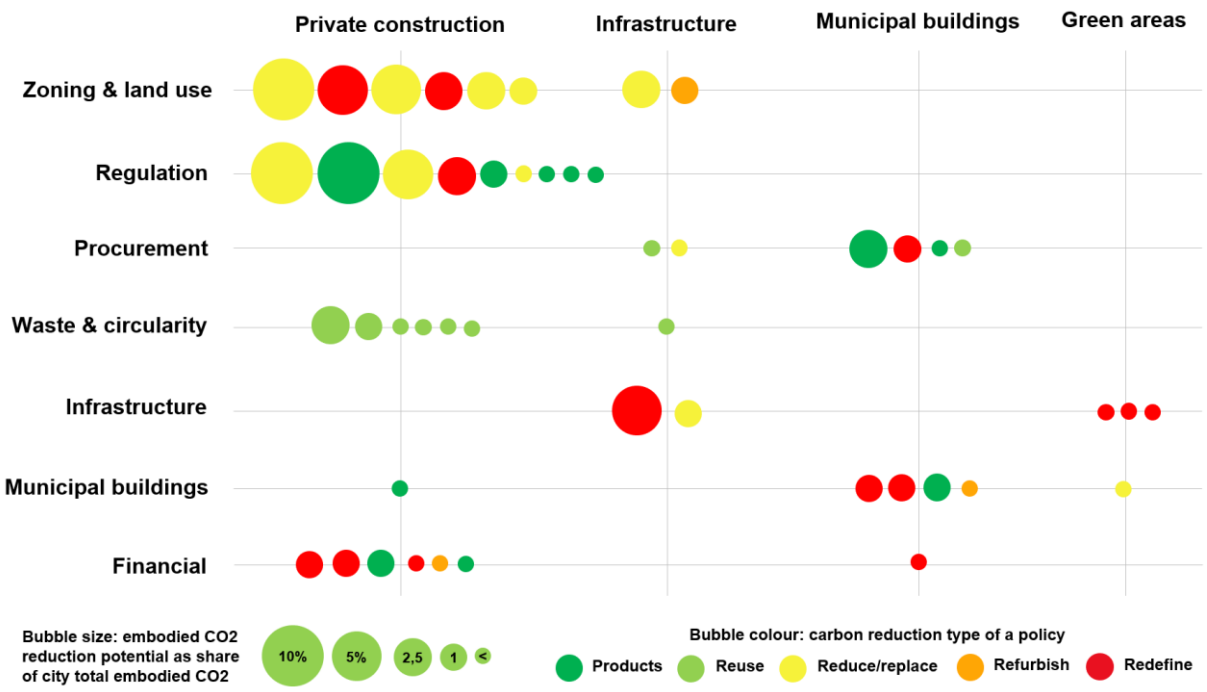
These policy types can be enacted by different city departments in different cities depending on the organisational model, as well as the jurisdiction the city holds.

These measures have an affect one or more built environment assets, which are grouped as follows:

- Private construction: means private residential, commercial, and industrial buildings as well as private infrastructure.
- Infrastructure: meaning all transport and utility networks and other civil works.
- Municipal buildings: class covers all buildings owned and / or used by the city.
- Green areas: class covers all green infrastructure, including unbuilt areas.

The policies and targeted assets are organized in the following matrix. The impact of the typologies of measures applicable for a specific policy-asset combination are represented by a colored circle. The high impact typologies are shown as larger circles and lower impact as smaller circles.

Figure 3 Embodied carbon policies in this report visualized per carbon reduction impact



The left top part of the visualisation clearly shows that 'Reduce & replace' materials as well as structures' (yellow) and 'Redefine the solution' (red) policy types have overall the highest impact. The highest impact policies are 'Zoning & land use' and 'Regulation' types. As private construction is the largest group of assets, those assets are also most influenced.

In other asset groups, the 'Redefine the solution' (red) type of policies have the highest impacts. 'Waste and circularity' policies have most impact on private construction, and 'Procurement' policies unsurprisingly have most impact on municipal buildings. Financial policies can also have a significant impact on private construction. Policies for 'Green areas' have a more limited impact. However, this report does not identify specific high impact policies for refurbishing assets.

3.3 EXAMPLES OF EMBODIED CARBON REDUCTION MEASURES FOR CITIES

Below are illustrative examples of embodied carbon reduction measures cities can adopt.

REDEFINE THE SOLUTION – EXAMPLES

- Using a "school as a service" concept to make use of underused spaces and deliver education without requiring new buildings to be built.
- Identifying an alternative means to deliver a need (e.g. if a leisure time facility is underused, the problem may relate to public transport access as opposed to needing to rebuild or renovate the building).
- Developing alternative low carbon systems – e.g. natural or low-impact development for stormwater management, not concrete stormwater routes.
- Deliver summer shading with foliage from trees instead of structures or systems.

REFURBISH EXISTING ASSETS – EXAMPLES

- Selling rights to convert a building to a different, more sought-after use.
- Extending existing buildings with modular, later moveable spaces.
- Renovations to increase usage efficiency in capacity, occupancy or both.

REDUCE & REPLACE MATERIALS AND STRUCTURES – EXAMPLES

- Reducing materials demand by zoning only materials-efficient building shapes.
- Reducing materials demand by requiring use of lighter or more efficient structures.
- Replacing materials with zoning provisions requiring use of low impact materials.

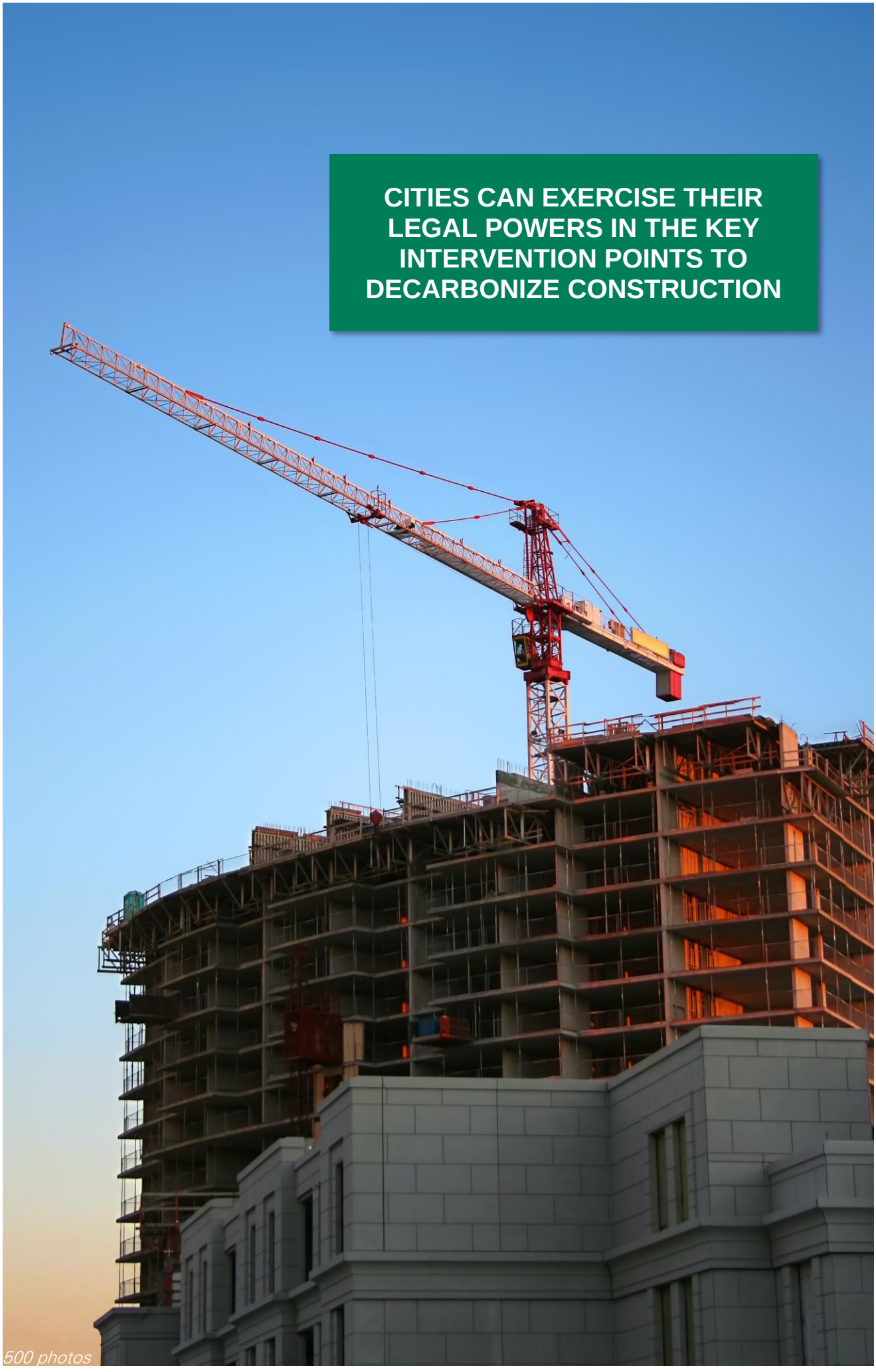
REUSE PRODUCTS AND MATERIALS – EXAMPLES

- Reducing materials destruction by requiring design for disassembly.
- Requiring salvaging specified materials from deconstructed buildings for reuse.
- Requiring cutting off brick & mortar facades as blocks and using in new buildings.

REQUIRE LOW CARBON PRODUCTS – EXAMPLES

- Specifying that all buildings must only use low carbon concrete or biogenic material.
- Specifying highest allowed emissions limits for selected materials using EPDs.
- Specifying low carbon products while limiting and/or substituting use of high carbon materials for lower impact ones.

CITIES CAN EXERCISE THEIR LEGAL POWERS IN THE KEY INTERVENTION POINTS TO DECARBONIZE CONSTRUCTION



4. LEGAL POWERS OF CITIES: CONTROL AND INFLUENCE

4.1 COMMON CITY PRIVILEGES IN EUROPE, UNITED STATES AND CANADA

4.1.1 LAND, INFRASTRUCTURE AND PROPERTY OWNERSHIP

Land, infrastructure and property ownership allows cities to tie carbon requirements to transactions. The more land the city owns, the more leverage this provides.

Cities commonly own significant amounts of land. Using their zoning privilege, they can enact land use changes. Also, cities have a unique position allowing them to purchase on a wholesale basis land that has no valid zoning. Then, cities can establish zoning and develop the land, including building basic infrastructure, as well as rezone any partly built areas. The exception to this is Canada, where much of the publicly owned land is owned by provincial or federal government.

Cities typically to own most underground infrastructure, as well as most of the ground-level infrastructure, with exception of national/state roads and rails. If metro lines are regional, then they may be in regional ownership, but the city may be a co-owner in such cases.

Cities own most of the buildings required for their own operations, and particularly in Europe, also own social housing companies. The actual ownership structures may range from direct ownership to more complex structures. The amount of building stock held varies by the scope of the services that the municipality provides. In many European countries, cities own most school and preschool properties, sports and recreation buildings as well as often also social housing buildings, making the cities large property owners in their own right. Depending on the country, cities may also own part of the care and medical services building stock directly or via a regional organization. The building stock growth is usually linked to demographic changes or industrial shifts causing the need for new types of buildings.

4.1.2 LAND SALES AND LAND USE CONTRACTS

Land sales and land use contracts, including leases allow cities to add carbon requirements to agreements, or for tenders for awarding such agreements.

Cities sell and lease land to developers and can apply discretion on how this process works as well as on what factors land is awarded. This can include, for example, design competitions, negotiated sales, requests for proposals, competitive bids, and broker sales. City may give preference to potential purchasers based on the nature of

the proposed project or other factors, including the carbon impact of the proposed development. In Canada, purchasers who already own adjacent or nearby property may also be given an advantage.

Land sales are not subject to public procurement regulations (as cities are sellers), and cities can in principle set any requirements that market participants are willing to sign up for. This can include environmental requirements. Similar civil law-based agreements may be entered in by cities and developers for land use in other cases. For example, to allow building extension or for use and development of public infrastructure such as roads. However, if a land sales agreement is a de facto public procurement contract, then development agreements in Europe would have to also apply said rules (Auroux v Roanne).

In the United States, state municipal codes may place restrictions on the purposes for which a city can buy or sell property. In Canada, this tool matters less as cities own less land.

4.1.3 PROPERTY TAXATION

Property taxation may allow city to set specific criteria for tax rates, reliefs or also tax increases, which may be conditioned to carbon-linked requirements.

Cities have the rights to raise revenue by taxing property. Taxation rights are usually based on and framed by national or state legislation. When taxation privilege is enshrined in national or state law, changing the taxation basis is only possible within the framework of that law. In general, cities have the right to set tax rates within boundaries set in law, which may include, for example, set floors and/or caps on taxes collected. Varying the tax rates themselves on another basis than those set-in legislation is generally not feasible for most cities.

On the other hand, cities have the jurisdiction to offer performance-based or other rebates on property taxes. This can provide tools to steer and condition land use development.

Finally, the tax collection is at a municipal level in the US, Canada, UK and other European countries, but operated by the national tax agency in some European countries. The significance of the property taxes as part of municipal revenue varies, but they can be very important.

4.1.4 BUILDING PERMITTING AND SUPERVISION

Property taxation may allow city to set specific criteria for tax rates, reliefs or also tax increases, which may be conditioned to carbon-linked requirements.

Cities commonly are charged with building permitting and supervision and thus enforce a national or local code. Building supervision may also be tasked by the city to

supervise compliance with civil law agreements between cities and developers. Cities may also apply their discretion to allow expedited or reduced fee permitting as an incentive for projects.

Permits can only be granted or denied based on compliance with existing building code or law. In many European countries, legal compliance is implemented as written, without much room for interpretation or exceptions.

4.1.5 DEMOLITION PERMITTING

Demolitions lead to destruction or downgrading of materials. Reducing extent or frequency of demolitions supports increasing renovations and materials preservation.

Cities commonly exercise a right to review and approve demolition applications. Demolition applications may be subjected to conditions imposed by the city, which can include for example a pre-demolition audit. Applications generally may not be denied on a basis not supported by already existing policies

Demolition permits may not be granted to any protected or historical buildings. In Portland, Oregon (U.S) and Vancouver, BC (Canada), cities also apply requirements to deconstruct certain buildings meeting specified requirements instead of mechanical demolition.

4.1.6 CONSTRUCTION WASTE HANDLING AND MASS DISPOSAL PERMITTING

Waste handling regulations allow increasing material reutilization and recycling rates.

Cities do have the right to approve placement of waste containers required for construction or demolition on the city property (e.g. sidewalk). Conditions can be attached to the right to occupy the public space. This process applies to new construction, renovations and demolitions alike. Cities also are permitting bodies for temporary and permanent storage of excavated earth masses, when that would take place within the city territory.

4.1.7 INFRASTRUCTURE AND CIVIL WORKS CONSTRUCTION

Cities are major construction clients and can leverage their purchasing power to set low carbon requirements for projects, materials and foster creation of data and knowledge for the local marketplace to support also market-driven development.

While mostly not based on a regulated monopoly, cities often exercise a de facto monopoly in the construction of several types of infrastructure; including public works, public and private transport, parks and at the times water and sanitation infrastructure. Cities, utilities they own, or in some cases private utility companies oversee these construction works. Cities or other regulators may continue to exercise power over

private utilities, including on carbon reduction (e.g. in case of Anglian Water, UK), but this is not a rule as such. Cities may also be co-investors in national or regional transport infrastructure. In addition, some cities do preliminary construction works prior to selling land to private developers.

Solid waste management is generally a cooperative effort involving different levels of jurisdiction from municipal to regional, state and federal level.

In the United States, public power infrastructure projects are often funded through the issue of tax-exempt municipal bonds, which gives cities and constituents greater input. In Europe, many cities have historically owned their own power plants, but most of those have been divested and are now part of regional, national or international utility companies. As this is not based on legal privileges, there are a number of variations.

4.2 PRIVILEGES THAT DIFFER BETWEEN EUROPE AND NORTH AMERICA

4.2.1 ZONING/PLANNING

Zoning sets indirectly the range of the minimum and maximum carbon impacts of an area. Cities commonly enjoy a zoning privilege, in effect regulating what can be built and where. Cities can also decide on used materials, building heights, and building shapes to mention a few and in some cases, stricter than country/area minimum performance requirements for construction works. Zoning can restrict the allowed building area, density, height, types of spaces allowed, parking requirements, as well as details of materials, appearance as well as other criteria.

EUROPEAN UNION AND EEA	UNITED STATES	CANADA
Generally, cities enjoy a planning monopoly. In most countries, only a city can make a formal proposal for a zoning plan. The private sector may file an application for rezoning. However, in Norway, both the city and developers can prepare zoning plans. An estimated 80-90 % of zoning plans are proposed by private developers, who submit them to the municipality for political approval.	Through Zoning Enabling Acts, states authorize local governments to assert power over land use within their jurisdictions. The Supreme Court has upheld the constitutional power of cities to regulate land use. States may restrict zoning (e.g. Texas, Arizona, and Tennessee prohibit inclusionary zoning.) Other states, for example California, have charter cities that enjoy specific privileges.	Because in Canada the control of land and its uses is a provincial responsibility, municipalities and region are empowered to exercise zoning control by provincial governments. In some provinces, precedent has required that municipal and regional zoning plans comply with provincial policy statements. As a result, cities enjoying a charter city or charter-like status enjoy more privileges than other cities.

4.2.2 PUBLIC PROCUREMENT

Public procurement can include carbon requirements or carbon-based award criteria.

Municipal procurement exceeding the minimum amounts set in law is typically subject to public procurement legislation, which is set by the state/national legislation and in Europe it must follow the Public procurement directive. Cities can organize their procurement the way they prefer, either by centralizing it or allowing departments to organize their own procurement. Complexity of procurement processes may pose barriers for smaller companies. Government bodies can require recipients of grant funding for purchases to apply public tendering requirements as well. It's worth noting that for some cases in public procurement, it's also necessary to ensure conformance with the state aid rules of the relevant jurisdiction.

EUROPEAN UNION AND EEA	UNITED STATES	CANADA
Public procurement directive 2014/24/EU sets mandatory requirements. Key principles are proportionality and non-discrimination. It recommends using performance-based requirements. The regulation requires setting technical requirements, including for environmental aspects, using European Standards, when they are available for the subject matter (§42). In specific cases, labels may also be used. The directive allows using life-cycle costing to award a tender (§68). In Europe, public procurement criteria aimed to limit competition between local, domestic and European bidders could be illegal.	Municipal governments are generally responsible for adopting procurement policies and procedures for competitive bidding. Key principles are competition, fairness, and accountability. In some states, two or more local entities may undertake cooperative purchasing. States may create laws or provide guidelines for local governments to follow. In some cases, procurement criteria that can de facto constitute sole sourcing would be prohibited under state law.	Specific rules vary by province, but general principles are fairness and open competition. Government ministries and departments and, in certain provinces, entities that are funded by government are required to comply in accordance with binding procurement policies. The federal government may deem a supplier ineligible or suspend them from selling to government.

4.2.3 PRODUCT MARKET ACCESS

Limiting product market access allows to phase out or reduce prevalence of products with high carbon impacts.

Product market access regulations and privileges differ widely between Europe and North America. The European product market is underpinned by the free movement of goods principle, which basically means that once a product is introduced to the market in the European Union, it can be used anywhere in Europe if it fulfills applicable requirements. Product prohibition is not possible for cities within Europe.

EUROPEAN UNION AND EEA	UNITED STATES	CANADA
The Construction Product Regulation (2011) is the exclusive construction product market regulation in the EU. Information required for market access is captured in the CE label. CE labels must include Declaration of Performance (DoP) for products with harmonized standards. Prohibiting CE-labelled products is not possible and building supervision is required to verify that all products used are CE-labelled. For product categories with harmonized European Standards, public bodies may not require information that is not part of DoP. The CE-marking requirement is a significant impediment for reusing construction products, as all reused products – where the product changes owner (so is brought to the market) must be verified and labeled. Reuse by the same material owner is not affected.	Cities may prohibit products by ordinance unless their State Governments have passed legislation to prevent them from doing so (for example, as the state of Texas has done with HB 2439).	The power of cities to ban products depends on permission from the provincial Governments. Some provincial Governments have struck down municipal product bans as out of municipal jurisdiction. Even in provinces that have struck down some municipal attempts to ban products, other municipalities have been successful in passing and enforcing legislation that bans the same products. Still, outright bans on products are likely to be stronger at the provincial or federal level.

4.2.4 BUILDING CODE AND OTHER MANDATORY REQUIREMENTS

Building codes allow setting requirements that reduce carbon impacts to projects.

In Europe, building codes are written at a state or national level. Cities are often granted the right to enforce them by building supervision. However, cities may be able to set their own supplementary requirements. In the United States, many cities can set their own codes, although some states prohibit cities within them from deviating from setting a standard more stringent than the state code.

EUROPEAN UNION AND EEA	UNITED STATES	CANADA
Codes are written at a national level. Cities and regions commonly enjoy a privilege to set their additional own requirements applicable to all construction within their jurisdiction, which may be complementary or more demanding than national regulations. They may be set in zoning regulations, or in mandatory city construction supplementary standards. There are exceptions, for example in Sweden and Norway, where legislation to a large extent prohibits requiring improvements above the law.	Many cities can set their own requirements. Cities with code jurisdiction may adopt specified sections of a pre-existing model code, such as the International Building Code or a state level code into municipal regulations. Some states prohibit local governments from adopting more stringent building code requirements than the state level. States with this restriction include: Connecticut, Delaware, Florida, Hawaii, Idaho, Indiana, Kentucky, Maine, Michigan, Minnesota, New Hampshire, New Jersey, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, Virginia, Wisconsin. In addition, strict limits apply in Washington, North Dakota, Montana and Massachusetts. The right to set codes may further vary between commercial and residential construction.	Provincial and territorial governments set building codes based on national model codes. Municipalities do not have the power to determine their own building codes. Exceptions to this are charter cities, which include Vancouver, Montreal, Winnipeg, Saint John and Lloydminster. Some cities enjoy similar statuses which are granted via specific legislation.

4.2.5 CLEAN AIR AND GREENHOUSE GAS EMISSIONS REGULATIONS

Mostly, cities enjoy privileges to protect citizens' health from harmful air quality. This may take the form of limiting or regulating transport or other direct emission sources within the city, sometimes including carbon emissions.

EUROPEAN UNION AND EEA	UNITED STATES	CANADA
Greenhouse gas emissions regulation as such generally is regulated with EU Emission Trading Scheme as mandatory law. Cities have right to regulate health-harming emissions, including nitrogen oxides, particles, and others. They are also allowed to restrict use of vehicles and commercial properties to achieve air quality goals. In some EU states, this would allow cities to prohibit vehicles using specified fuels or types of tires from entering areas designated by city. The Finnish city of Lahti has a small scale non regulatory emissions trade pilot on personal transport (CitiCAP).	Numerous US states, including California, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont operate carbon cap and trade systems at the state level. Some cities have proposed or passed legislation directly regulating greenhouse gas emissions, through caps, emissions intensity limits, or other mechanisms. Because this is a new kind of attempt at regulation, its potential--and cities' ability to withstand state preemption and legal challenges--is not clearly known and will be defined as precedents accumulate.	Canada's provinces and territories can choose their approach to carbon pricing using either an explicit price or a cap-and-trade scheme. The Canadian Federal Government implements a federal-level pricing backstop that will apply to provinces and territories that either request this or that do not have an adequate pricing system in place. There are no known city level carbon trading systems in Canada. Quebec was the first Canadian province to introduce a carbon tax in 2007.

5. HOW THE POLICIES HAVE BEEN SELECTED AND EVALUATED

5.1 SELECTING, EVALUATING AND DOCUMENTING POLICIES

The policies present in this report were selected from a longlist of 71 policies based on a combination of votes of interest from the steering group consisting of some of the world's leading cities in climate policy, as well as the preliminary impact evaluation of Bionova experts. In addition, in the course of the project, some new policies were added and some initial ones were merged together. The report only considers policies that can be implemented today to respond to the climate emergency.

This project does not evaluate political appetite or feasibility for implementing any of the policies described; nor does it describe variability of impact, cost, enforceability or implementability that occur between different cities in different contexts.

The policies have been documented in a manner allowing an informed reader to start implementing and defining how the policy could look in their city.

Where examples have been identified, they have been provided. If a single comprehensive main example was found, it is provided. When several are found, they are generally summarized. In cases where no actual implementation exists, nothing has been recorded. Statements, roadmaps or declarations to act have not been considered for examples.

REPORT FINDINGS ARE DISTILLED FROM 71 POLICIES BASED ON PARTICIPATING CITIES' PRIORITIES AND IMPACT

5.2 CARBON IMPACT EVALUATION METHOD

The basis of the carbon impact evaluation is how much embodied carbon a policy can reduce over the next decade in the context that is in place today.

The carbon impacts have been estimated by Bionova experts based on a hypothetical one million inhabitant city with a growing demography and a typical concrete and steel-based construction industry. For purposes of estimation, the city has been assumed to be in possession of privileges allowing effective and comprehensive implementation of policy. While indicative ranges for impacts are given, actual values will vary e.g. based on construction typology, seismicity, ownership of building stock, growth rate and other factors.

Each additional black dot doubles the carbon reducing impact of a policy. More black dots correspond to higher carbon reduction impact. It is important to understand that the policies in the municipal buildings category would have approximately ten times higher impact if elevated to the level of regulations to cover all private construction.

IMPACT	CONDITIONS FOR THIS CARBON IMPACT RATING AND INDICATIVE IMPACT RANGE
●○○○○	This policy's direct impacts are below 1 % of city's overall embodied carbon. At the same time, the policy can be an important enabler for other policies. *Example policy: Green Lane for Permitting Low Carbon Projects. This must offer a credible time saving in the permitting process and be easy enough to implement to be attractive. It is not considered able to mobilize a significant number of projects.*
●●○○○	This policy's impacts are estimated between 1-2,5% of embodied carbon.
●●●○○	This policy's impacts are estimated between 2,5-5% of embodied carbon.
●●●●○	This policy could reduce overall embodied carbon by at least 5%. Example: affects one-third of city's overall embodied carbon and cuts 20%; or affects one-half and cuts 10%.
●●●●●	This policy could reduce overall embodied carbon by at least 10%. Example: affects half and cuts 20%; or affects one quarter and cuts 50%. *Example policy: Embodied carbon intensity targets for zoning. This will basically be able to enforce carbon limits for all newly zoned areas (but will not have an impact on areas with existing zoning)*

5.3 COST EFFICIENCY EVALUATION METHOD

The basis of the cost efficiency evaluation method is how cost-efficient a policy is to implement (either for the private sector in private projects or the public sector in public projects). This method does not consider if the city may need to increase human resources, procure services or set up a mechanism for reporting or verification.

Cost efficiency has been evaluated by Bionova experts based on the defined categories of cost efficiency introduced below. All typically available manufacturing, services, facilities and skills required for the implementation of the policy are assumed to be in place and their investment costs are assumed to be borne by the respective private sector stakeholders. The situation assumes a city where low carbon construction is not new, but not yet implemented by the whole market either. The method assumes that the market will adjust to new situations, thus any short-term adaptation period costs are not considered. When a policy only impacts short-term costs, the evaluation basis is short-term; when it has longer term impacts, the basis is long-term. The cost evaluation does not consider which party or parties are beneficiaries of any savings. While indicative ranges for cost efficiency are given, these should not be considered specific values. More dots correspond to higher cost efficiency.

EFFICIENCY	CONDITIONS FOR THIS COST EFFICIENCY RATING
●○○○○	This policy has considerable direct additional costs of implementation.
●●○○○	This policy has direct additional costs of implementation. *Example policy: Plant trees in city spaces and poorly constructible areas. This action needs to be funded out of the budget and creates no direct savings for anyone (but may have longer-term gains).*
●●●○○	This policy can be considered cost-efficient. Depending on specific circumstances, the market could end up in cost parity with and without this policy. All carbon tax/fee and competition-based policies are in this category as those allow market players to optimize costs.
●●●●○	This policy may save costs or is highly cost-efficient.
●●●●●	This policy can save costs significantly. It may still require enforcement to happen as cost savings may not be captured by the party making choices. *Example policy: Density bonus for carbon efficiency. This policy allows developers to create more space at a lower cost, and is very lucrative. The city may lose on fee income, however.*

5.4 EASE OF IMPLEMENTATION EVALUATION METHOD

The basis of the ease of implementation evaluation method is how difficult implementing a policy in practise to a comprehensive scale would be. This method assumes that political will for implementation is in place in the city council. For purposes of estimation, the city has been assumed to be in possession of privileges allowing effective and comprehensive implementation of the policy. Ease of implementation has been evaluated by Bionova experts based on the below defined categories.

All typically available manufacturing, services, facilities and skills required for the implementation of the policy are assumed to be in place. The evaluation does not consider difference between implementing policy in a short timeframe or with a long advance notice. While indicative ease of implementation rankings is given, these are to be adjusted by each city. More dots mean the policy is easier to implement.

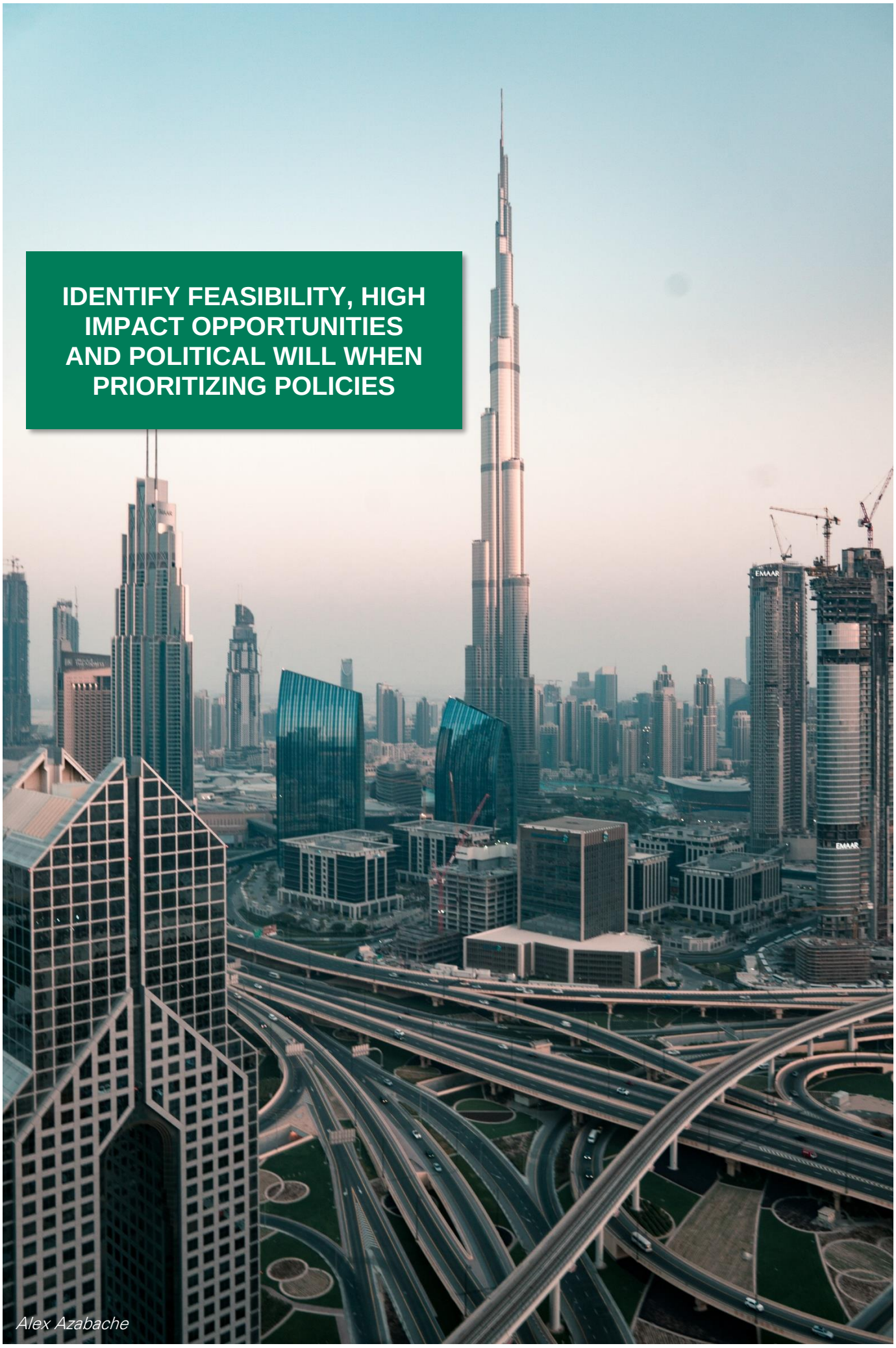
EASE	CONDITIONS FOR THIS EASE OF IMPLEMENTATION RATING
●○○○○	Very difficult. This policy requires significant new investments or development of new skills, practises or standards beyond those generally available today.
●●○○○	Difficult. This requires a change of well-established business practises in a way that can be expected to create noticeable resistance for the new policy.

EASE	CONDITIONS FOR THIS EASE OF IMPLEMENTATION RATING
	Example policy: Low carbon cement and concrete policy. These policies (depending on implementation) can change several business practises. Such policies would create resistance to change.
●●●○○	Average. This is expected to require effort and determination to implement. All policies where the municipality is the actor are at least at this level.
●●●●○	Easy. This policy is expected to be easy to implement, but may require time for legislative adoption. *Example policy: Parking requirement optimization. As a general rule, most cities have required building a specific number of parking spaces. This has created additional costs for developers and clients. Reducing these is easy.*
●●●●●	Very easy. This policy can be expected to be very easy to implement and be of interest to market players, and can be adopted immediately. All information policies are in this category.

5.5 ENFORCEABILITY EVALUATION METHOD

The basis of the ease of enforceability evaluation method is how difficult the policy's actual compliance is to make happen, including monitoring and verification. For purposes of estimation, the city has been assumed to be in possession of the authority, the technical capability and other means to carry out necessary verifications. Enforceability has been evaluated by Bionova experts based on the below defined categories. While indicative enforceability rankings are given, these are to be adjusted by each city. More dots correspond to a policy that is easier to enforce.

ENFORC.	CONDITIONS FOR THIS ENFORCEABILITY RATING
●○○○○	Compliance is difficult to achieve and very hard to verify and/or monitor. It could be monitored via whistle-blowers for example.
●●○○○	Compliance with this policy is difficult to achieve and hard to verify and/or monitor. It could be monitored through testing or reviews. *Example policy: Prohibit extremely high emitting materials. Blowing agents are only feasible to monitor through materials tests, except on site blowing.*
●●●○○	Compliance with this policy can be achieved, verified and monitored through paper trail. Spot checks on site would reveal any deviations.
●●●●○	This policy is easy to achieve and enforce, and compliance is easy to verify. The policy can use market-based monitoring or third-party verifications. All policies where the municipality is the key actor are at least at this level. *Example policy: Increased property tax for unoccupied properties. This policy is feasible to enforce as part of standard tax declaration and collection.*
●●●●●	Implementing this policy does not require any enforcement. All information policies are in this category.


IDENTIFY FEASIBILITY, HIGH IMPACT OPPORTUNITIES AND POLITICAL WILL WHEN PRIORITIZING POLICIES
EMAAR
EMAAR
Alex Azabache

6. DEVELOPING THE POLICY TOOLKIT FOR YOUR CITY

6.1 DEVELOPING YOUR OWN COMBINATION OF POLICIES

This project does not recommend what policies a city should adopt. That depends the city's situation, resources, the status of local market and other factors. This report provides a range of options from which a city can identify solutions it could implement, which it can then evaluate against its own objectives and situation. The city needs to make the decisions on priorities between carbon reduction and other objectives, where they are not aligned.

The following steps are a good start to achieve the list of most applicable policies.

1. IDENTIFY WHICH POLICIES ARE CONSIDERED FEASIBLE.
   Start by understanding what is possible in your local market, and what capabilities your local businesses have. Cities can find out more about the situation for example by identifying the local relevant members of the World Green Building Council and discussing the matter with their experts.
2. IDENTIFY WHICH POLICIES YOUR CITY CAN LEGALLY IMPLEMENT.
   Consult your legal department on this to screen policies for applicability. You can leave out scope of the policies which depend on another layer of jurisdiction. However, you can still lobby other layers of jurisdiction to enable enacting those policies.
3. IDENTIFY WHICH POLICIES TARGET HIGH VOLUME ACTIVITY.
   If a city is in a rapid phase of expansion, the pace of new construction is likely to be very high. But if a has a stable population, renovation and circularity policies may have a higher impact.
4. CONSIDER THE AVAILABLE POLITICAL WILL TO IMPLEMENT.
   A great policy that is not adopted is less useful than a good policy that is adopted. Therefore, getting a sense of political support for a new policy is an advisable step, and understanding what additional benefits policies provide.
5. REFINE THE POLICIES TO AN ACCEPTABLE AND IMPLEMENTABLE FORM.
   Many of the policies can be easily adapted to local circumstances. Many of the policies can also be transformed from hard requirements to incentives, or vice versa. Work the policies to meet the level of rigour that is going to be possible to implement. Some policies may also be adjusted to target building life-cycle emissions instead of embodied carbon emissions only.
6. COMBINE INCENTIVE MEASURES WITH REQUIREMENT MEASURES.
   Some of the policies save money directly for the industry. Enabling those can act as a counterweight to additional carbon reducing requirements that have an added cost to impact.

6.2 USING INCENTIVES AS PART OF YOUR TOOLKIT

This report includes some policies with mandatory requirements for all projects, some with requirements that only apply to municipal projects, some that are voluntary programs, and some that provide incentives for those who undertake voluntary embodied carbon reduction measures. Many of the policies written as mandatory requirements could also be implemented as voluntary incentive-based programs. Also, many policies written to apply to municipal projects could be expanded to cover all projects through incentive programs.

For any incentive program, the following criteria must be defined:

- Eligibility: What kinds of buildings or projects are eligible? This may vary based on zoning type, project size or type, location within the jurisdiction, or other factors.
- Requirements: What requirements must an eligible building or project fulfil in order to be awarded the incentive? What technical capacity is required to enforce the awarding of the incentives, and should it be internal or third party?
- Value of the incentive and beneficiaries: What is the benefit awarded to eligible buildings or projects that meet the defined requirements, and who are the beneficiaries? Incentive types covered in this report include:

  Land use incentives: A density bonus is a land use incentive that allows for an exemption from the base zoning code, permitting a building to exceed the maximum height, floor area ratio, or density generally permitted in its zone. These incentives typically benefit the developers.

  Permitting incentives: Expedited or reduced fee permitting allows projects to move through the permitting process more rapidly, more easily, or less expensively. Permitting incentives are most effective when long typical processing periods create a wait time or financial cost. These incentives typically benefit the owners or designers.

  Financial Incentives: Property tax or council tax rebates, direct grants, and other financial incentives reduce or subsidize costs or give money (through rebates, grants, or other means) to project stakeholders. These incentives typically benefit the owners.

  Incentives should be chosen based on their likely impact given local conditions, the ability of the administrative authority to offer them, and how effectively they can leverage existing local incentives (such as those by utilities or other levels of government) to decrease costs.

6.3 TOOLS AND RESOURCES FOR IMPLEMENTING THE POLICIES

The following tools are listed to provide cities implementing the policies described in this report access to some potentially relevant solutions available on the market. The list is covering some selected tools for each policy type. The tools have been selected with applicability for major cities, and for relevance in North America and Europe. Cities have also developed tools for their own use, but most without a wider adoption.

In addition to these tools, other actors offer resources that can be relevant for cities in their embodied carbon work – for example the national Green Building Councils and the Carbon Leadership Forum.

TOOLS FOR ZONING AND LAND USE

TOOL	CATEGORY	GEOGRAPHY	POLICIES
Residential density / living space indexes, for example EuroStat Housing Conditions statistics	Benchmark	Europe	Z5
Parking place density indexes – local statistics or services such as Parkopedia (commercial)	Benchmark	Global	Z4
Building typology embodied carbon guidance or optimization tools such as Carbon Designer (commercial)	Guidance / Software	EU, US, CA	Z1, Z8

TOOLS FOR BUILDING REGULATION AND SUPERVISION

TOOL	CATEGORY	GEOGRAPHY	POLICIES
Building carbon limits – for example Carbon Leadership Forum (North America), RIBA (UK), Carbon Heroes Benchmark Program (Europe)	Benchmark	EU, US, CA	R1
Software for project embodied carbon (free) - Embodied Carbon in Construction Calculator EC3	Software	U.S., Canada	R1, R9
Software for embodied and life-cycle carbon, LCA, LCC and product EPD (free & paid) - One Click LCA	Software	Global	R1, R3, R6, R9
EN 15978 - Environmental Assessment of Buildings – building LCA standard (CEN)	Standard	Europe, Global	R1, R3, R6, R9

Also, the procurement tools can be applied here.

TOOLS FOR PROCUREMENT

TOOL	CATEGORY	GEOGRAPHY	POLICIES
Bay Area Low-Carbon Concrete Codes and Norwegian Low Carbon Concrete Standard -targeted standards for low carbon concrete	Standard	U.S, Norway	P1, R2
UK CARES Sustainable Reinforcing Steel Certificate – for market-neutral sustainable steel purchasing	Certificate	UK	P1

Also, the Green Public Procurement Guideline can be applied in projects in Europe.

TOOLS FOR INFRASTRUCTURE

TOOL	CATEGORY	GEOGRAPHY	POLICIES
PAS 2080: Carbon Management in Infrastructure - methodology for infrastructure carbon reduction	Standard	UK	I1
Climate Positive Design – landscaping carbon sequestration design software (free)	Software	U.S., Canada	I4, I5
Climate Lens – standard for low carbon infrastructure projects	Standard	Canada	I1

TOOLS FOR WASTE & CIRCULARITY

TOOL	CATEGORY	GEOGRAPHY	POLICIES
Guidelines for the waste audits before demolition and renovation works of buildings	Guidance	Europe	W2
ISO 20887 Design for disassembly and adaptability — Principles, requirements and guidance	Standard	Global	W1
Circular Economy in Cities resources from the Ellen Mac Arthur Foundation for construction	Guidance	Global	Several, P6
Municipality-led circular economy case studies by C40 Cities – includes construction relevant cases	Guidance	Global	Several, P6

TOOLS FOR MUNICIPAL BUILDINGS

TOOL	CATEGORY	GEOGRAPHY	POLICIES
Space use and occupancy efficiency benchmarks, e.g. GSA (U.S.)	Benchmark	Global	M1
EU Green Public Procurement Criteria for Offices criteria for holistic project sustainability	Standard	Europe	P2

TOOLS FOR FINANCIAL POLICIES

TOOL	CATEGORY	GEOGRAPHY	POLICIES
Pricing carbon: World Bank Carbon Pricing Dashboard & Carbon Pricing: CDP Disclosure Best Practice	Benchmark	Global	F1, F2, F3, F4
EU report: Improving management of construction and demolition waste – for setting landfill taxes	Guidance	Global	F6, F8
The Net Zero Carbon Buildings Commitment by the World GBC – has currently 28 cities signed up	Benchmark	Global	F5

6.4 RESOURCES PROVIDED BY THE PROJECT TEAM

Technical assistance to support implementation of policies in this report is provided in form of a webinar videos available at www.embodiedcarbonpolicies.com.

Bionova Ltd's One Click LCA Planetary is a free embodied carbon tool for everyone, anywhere. This tool bases on the One Click LCA platform, which has a global materials database, and supports nine languages. The tool is brought to the users in cooperation with national Green Building Councils in various countries. It supports implementation of policies defined in this report, including Z3, R1, R2, R6, R9, P1, I1, M2 and M3.

Architecture 2030's Carbon Smart Materials Palette is an immediately applicable, high-impact pathway to embodied carbon reductions in the built environment. It identifies in a clear and visual manner high-impact materials as well as Carbon Smart materials, which are either low carbon or carbon sequestering, and provides guidance on how to choose materials and what to pay attention to achieve low carbon outcomes.

In addition, the C40 Cities Clean Construction Policy Explorer complements this report by displaying the actions cities around the world are already taking to embrace clean construction and supporting embodied carbon reductions in their built environment. This interactive dashboard demonstrates that leading city action is possible and underway, serving as inspiration to accelerate these efforts elsewhere.

7. SUMMARY OF EMBODIED CARBON REDUCTION POLICIES

The embodied carbon reduction policies in this report are synthetized in the below table with their key performance data by category. The sum of scores is the sum of carbon impact, cost-efficiency, implementability and enforceability points. The examples provided column lists the cities from which examples are provided in this report in the specific policy cards. Policies are sorted first in order of descending carbon impact, and in case of tie, always in descending order of the next column on right.

ZONING AND LAND USE POLICIES

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
Z1	EMBODIED CARBON TARGETS FOR ZONING PROCESS	●●●●●	●●●●○	●●●○○	●●●●○	16	-
Z2	SET ZONING REQUIREMENTS FOR BIO-BASED MATERIALS	●●●●○	●●●○○	●●●●○	●●●●○	15	Helsinki
Z3	CARBON-SCORED LAND SALES COMPETITIONS	●●●●○	●●●○○	●●●○○	●●●●○	14	Porvoo, Tampere
Z4	PARKING REQUIREMENT OPTIMIZATION	●●●○○	●●●●●	●●●●○	●●●●●	17	London, Portland, Helsinki
Z5	APARTMENT SIZE AND SPACE EFFICIENCY GUIDELINES	●●●○○	●●●●●	●●●●○	●●●●●	17	NYC
Z6	PREFABRICATED OR MODULAR CONSTRUCTION PRIORITY	●●●○○	●●●●○	●●●○○	●●●●○	14	-
Z7	INCREASING DENSITY USING EXISTING INFRASTRUCTURE	●●○○○	●●●●○	●●●●○	●●●●○	14	-
Z8	USE LOW CARBON BUILDING TYPOLOGIES IN ZONING	●●○○○	●●●○○	●●●●○	●●●●●	14	-

BUILDING REGULATION AND SUPERVISION

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
R1	LIFE-CYCLE CARBON LIMITS FOR NEW BUILDINGS	●●●●●	●●●○○	●●●○○	●●●○○	14	Vincent, Douro-Dummer, London
R2	LOW CARBON CEMENT AND CONCRETE POLICY	●●●●●	●●●○○	●●○○○	●●●○○	13	Singapore, Masdar City, Portland, Dubai
R3	MATERIAL-EFFICIENT STRUCTURAL DESIGN REQUIREMENT	●●●●○	●●●●●	●●●○○	●●●○○	15	Singapore, San Francisco, Los Angeles, Seattle
R4	DENSITY BONUS FOR CARBON EFFICIENCY	●●●○○	●●●●●	●●●●○	●●●●○	16	Seattle, Washington, other US cities, Singapore
R5	ZERO CARBON CONSTRUCTION SITES	●●○○○	●●○○○	●●●●○	●●●●○	12	Trondheim, Oslo, Malmö, Göteborg, Stockholm
R6	CONSTRUCTION MATERIALS EFFICIENCY DECLARATION	●○○○○	●●●●○	●●●●○	●●●●○	13	-
R7	EXPEDITED PERMITTING FOR LOW CARBON PROJECTS	●○○○○	●●●○○	●●●●○	●●●●●	13	San Diego, Seattle
R8	PROHIBITING EXTREMELY HIGH EMITTING MATERIALS	●○○○○	●●●○○	●●●○○	●●○○○	9	North Bend, Washington, Tuttle
R9	LIFE-CYCLE CARBON CALCULATION AND REPORTING	●○○○○	●●●○○	●●●●○	●●●●○	12	London

PROCUREMENT

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
P1	CARBON LIMITS FOR BUILDING MATERIALS PROCUREMENT	●●●○○	●●●○○	●●●●○	●●●●○	14	Trondheim
P2	GREEN PUBLIC PROCUREMENT FOR CITY BUILDINGS	●●○○○	●●●○○	●●●○○	●●●●○	12	Trondheim
P3	REQUIREMENT OF RECYCLED AGGREGATES	●○○○○	●●●●○	●●●●○	●●●●○	13	Copenhagen
P4	LOW-CARBON ASPHALT PROCUREMENT	●○○○○	●●●○○	●●●●○	●●●○○	11	-
P5	REQUIRE USE OF CERTIFIED WOOD PRODUCTS	●○○○○	●●●○○	●●●○○	●●●○○	10	-
P6	CIRCULAR MATERIALS PURCHASING STRATEGY	●○○○○	●●○○○	●●●○○	●●●○○	9	Rotterdam

INFRASTRUCTURE

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
I1	EARLY DESIGN CARBON TARGETS FOR INFRASTRUCTURE	●●●○○	●●●●○	●●●○○	●●●●○	14	Stockholm
I2	WOOD FOR LIGHT BRIDGES AND SMALLER STRUCTURES	●●○○○	●●●○○	●●●●○	●●●●●	14	-
I3	USE VEGETATION FOR WATER MANAGEMENT	●○○○○	●●●●○	●●●●○	●●●●○	13	Helsinki
I4	PARK MANAGEMENT FOR CARBON SEQUESTRATION	●○○○○	●●●○○	●●●●○	●●●●●	13	-
I5	PLANT TREES IN CITY SPACES AND UNBUILDABLE AREAS	●○○○○	●●○○○	●●●●○	●●●●●	12	-

WASTE AND CIRCULARITY

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
W1	DESIGN FOR DISASSEMBLY AND ADAPTABILITY CRITERIA	●●●○○	●●●●●	●●●○○	●●●○○	14	-
W2	MANDATORY PRE-DEMOLITION AUDITS AND DATA SHARING	●●○○○	●●●●●	●●●○○	●●●●○	14	-
W3	MANDATORY MATERIAL TAKEBACK PROGRAM	●○○○○	●●●●●	●●●●○	●●●●○	14	-
W4	SOIL COORDINATION FOR MASS STORAGE AND REUSE	●○○○○	●●●●●	●●●●○	●●●●○	14	Helsinki, Espoo
W5	INFORMATION ON ADAPTABILITY AND WASTE REDUCTION	●○○○○	●●●●○	●●●●●	●●●●●	15	-
W6	MATERIALS LONGEVITY POLICY	●○○○○	●●●●○	●●●○○	●●●●○	12	-
W7	ESTABLISH OR SUPPORT MATERIALS REUSE FACILITIES	●○○○○	●●●○○	●●●●●	●●●●●	14	Seattle, Washington
W8	CARBON REDUCTION OR SALVAGING REQUIREMENT FOR DEMOLITIONS	●○○○○	●●●○○	●●●○○	●●●○○	10	Vancouver, Portland, London (Camden)
W9	MANDATORY CONSTRUCTION AND DEMOLITION WASTE LANDFILL DIVERSION	●○○○○	●●●○○	●●●○○	●●○○○	9	San Francisco, Trondheim

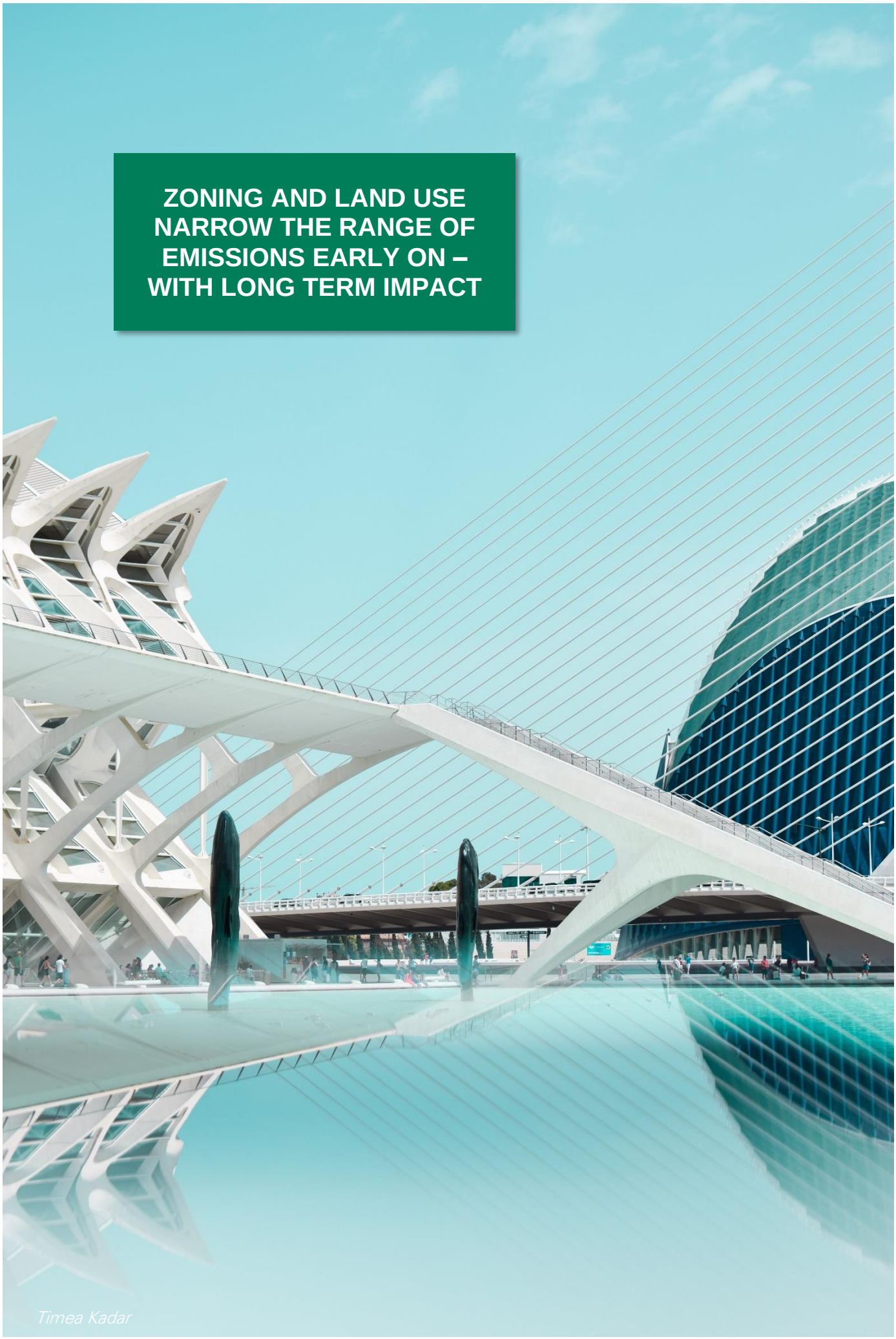
MUNICIPAL BUILDINGS

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
M1	SPACE USE AND OCCUPANCY EFFICIENCY	●●○○○	●●●●●	●●●●○	●●●●○	15	-
M2	EMBODIED CARBON LIMITS FOR NEW & LEASED BUILDINGS	●●○○○	●●●○○	●●●●○	●●●●○	13	Trondheim, Tampere
M3	USE CARBON AS A CRITERION FOR DESIGN COMPETITIONS	●●○○○	●●●○○	●●●○○	●●●●○	12	Helsinki
M4	LOW CARBON SITES, SOIL STABILIZATION AND FOUNDATIONS	●○○○○	●●●●○	●●●○○	●●●●○	12	Helsinki
M5	PUBLICIZE BEST PRACTISES AND CASE STUDY PROJECTS	●○○○○	●●●○○	●●●●●	●●●●●	14	Oakland
M6	RENOVATION VS. KNOCK DOWN AND REBUILD COMPARISON	●○○○○	●●●○○	●●●●○	●●●●○	12	Lahti
M7	SALVAGED, REUSED OR RECYCLED MATERIAL MINIMUMS	●○○○○	●●●○○	●●●●○	●●●○○	11	-

FINANCIAL POLICIES

POLICY CODE	POLICY NAME	CARBON IMPACT	COST-EFFICIENCY	IMPLEMEN-TABILITY	ENFORCE-ABILITY	SUM OF SCORES	EXAMPLES PROVIDED
F1	TAX REBATES FOR LOW CARBON DEVELOPMENTS	●●○○○	●●●●●	●●●●○	●●●●○	15	Milford
F2	INCREASED PROPERTY TAX FOR UNOCCUPIED PROPERTIES	●●○○○	●●●●●	●●●○○	●●●●○	14	Vancouver
F3	LINK LAND USE FEES TO PROJECT LIFE-CYCLE CARBON	●●○○○	●●●●●	●●○○○	●●●○○	12	-
F4	CARBON PERFORMANCE GRANTS FOR PROJECTS	●●○○○	●●○○○	●●●●●	●●●●○	13	Douro-Dummer, Voralberg
F5	INCLUDE EMBODIED CARBON IN CLIMATE ACTION PLAN	●○○○○	●●●○○	●●●●●	●●●●●	14	San Francisco, Boston
F6	INCREASE DEMOLITION PERMITTING FEES	●○○○○	●●●○○	●●●●○	●●●●○	12	-
F7	INCENTIVES FOR MANUFACTURERS TO REDUCE CARBON	●○○○○	●●●○○	●●●●○	●●●●○	12	-
F8	LANDFILL TAX ON CONSTRUCTION AND DEMOLITION WASTE	●○○○○	●●●○○	●●●●○	●●●○○	11	-

ZONING AND LAND USE NARROW THE RANGE OF EMISSIONS EARLY ON – WITH LONG TERM IMPACT



Timea Kadar

8. ZONING AND LAND USE

Z1 EMBODIED CARBON TARGETS FOR ZONING PROCESS

REDUCE & REPLACE MATERIALS AND STRUCTURES

LAND USE & ZONING

CARBON IMPACT	●●●●●	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●●○	ENFORCEABILITY	●●●●○

SUMMARY

Zoning for new areas or rezoning existing areas can be implemented using carbon evaluation or early phase carbon intensity metrics to ensure zoning is resulting to low carbon built environment. Decisions made in the zoning phase have very high potential impact, starting from choosing the land to zone and to build on, moving to determining constraints for density, massing and height. Also parking and transport infrastructure, as well as detailed requirements set for the builders are determined in zoning.

VARIANTS

In jurisdictions allowing this to happen, cities can attach mandatory regulatory requirements for buildings to be built in the zoned areas, potentially including indirect or directly applicable carbon performance requirements, as well.

Identify areas where soil is unstable, or is soft and deep, and thus requires very costly and carbon intensive stabilization and foundations; avoid zoning and permitting buildings on such land at all. Such land could be used for less intensive construction.

Avoid requirements that lead to large amount of underground or tower parking.

BENEFITS

Many of the zoning stage decisions have a significant and irreversible impact on carbon emissions from materials, energy as well as transport. In particular, underground and infrastructure embodied carbon impacts are locked in in zoning.

PRE-REQUISITES

City must have a zoning authority and technical ability to evaluate carbon impacts from zoning.

ENFORCEMENT

Internal enforcement (as in, applying policy in the zoning process) is the only form of enforcement, as same zoning regulation enforcement would apply generally.

Z1 - SPOTLIGHT: Norway, UK and Finland

Building typology embodied carbon impacts have been considered for zoning purposes in individual district level zoning projects in Norway or UK. Zoning exercises considering operating carbon have been done in Finland.

Z1 – EXAMPLE LANGUAGE

Any zoning project shall, before commencing, be evaluated for soil stabilization and improvement, foundations and infrastructure construction carbon impacts to ensure they do not compromise city carbon reduction objectives. For pre-construction and infrastructure, the embodied carbon impacts shall be calculated using an EN 15978 / ISO 21930 compliant method for a 60-year calculation period. Results shall be reported separately for major sub-districts or areas of the entire district.

Sub-districts or areas causing very high embodied carbon emissions shall be avoided to be built and used for green areas and recreation, to the extent possible. Areas with good soil and lower embodied carbon impacts shall be prioritized for construction, and volume of construction shall be centralized, also considering factors, such as transport accessibility and others.

In a further step in the zoning process for massing the district, different building typologies for key soil types shall be calculated for the embodied carbon impacts using an EN 15978 / ISO 21930 compliant method for a 60-year calculation period. Results shall be reported separately for major building typologies for key soil types. These calculations shall include the building sub- and superstructure, as well as envelope and foundations and parking structures, and omit finishes and services.

Building typologies causing impacts above 500 kg CO2e / m2 gross floor area shall be optimized by zoning regulations. Such optimization shall result into a set of feasible requirements allowing achieving targeted embodied carbon impacts. This requirement can be waived, if setting such requirements would render construction unfeasible or compromise optimal carbon impacts from transportation or energy use.

Z2 SET ZONING REQUIREMENTS FOR BIO-BASED MATERIALS

REDUCE & REPLACE MATERIALS AND STRUCTURES

LAND USE & ZONING

CARBON IMPACT	●●●●○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●○○	ENFORCEABILITY	●●●●○

SUMMARY

Zoning regulations requiring that buildings are built predominantly with wood or bio-sourced materials (e.g. bamboo, straw) for primary frame and façade from 100 % sustainable sources. Either the zoning or a supporting regulation should require use of wood from sustainable sources.

VARIANTS

Alternatively, regulations could set a minimum share of bio-sourced material. A specific form of this requirement would be requiring that the primary structural frame of the building must be wood or bio-sourced materials for 75 % or more of the building by floor area. Maximizing carbon storage would be possible by requiring minimum amount of wooden structures. However, this may lead to less efficient use of structural materials. Finally, to maximize positive climate impact, such structures could be subject to design for disassembly requirements, allowing their future reuse (as opposed to incineration).

BENEFITS

Setting direct requirements for use of wood or bio-sourced materials leads to increasing carbon storage. Furthermore, when regulations ensure sustainable sources for wood, this will almost always lead to reduced embodied carbon emissions.

PRE-REQUISITES

City must have a zoning authority that covers types of materials that can be used, and capacity for ensuring that all bio-based material used for this is sustainably sourced. If sustainably sourced bio-based materials are not readily commercially available, this policy may not be appropriate.

ENFORCEMENT

This is based on general enforcement of zoning by-laws. Planning permission applications would have to demonstrate compliance with the zoning by-laws.

Z2 - SPOTLIGHT: Helsinki and Voralrberg

City of Helsinki, Finland has applied wood requirements in several district zoning projects. The district zone of Honkasuo required that all buildings in the district must have a wooden frame and façade. Furthermore, detached houses were required to be built with massive wood. This particular zoning regulation was contested in the Supreme Administrative Court of Finland in favor of the zoning regulation as written (KHO:2015:56). According to the court, the zoning authority of the municipality followed the law, and the authority of the municipality to regulate the construction is not limited only to the visual appearance of the buildings. The current Carbon Neutral Helsinki 2035 program requires zoning officials to incorporate carbon reducing practices in zoning. These include zoning for wood in buildings.

In a different form, yet targeted towards similar ends, the Austrian state of Voralrberg provides grants for low operating or embodied carbon new houses. For example, a wood-cladding grant is 20 €/m2 and renewable insulation is 30€/m2. Austrian national embodied impact system classifies building impacts using an index called ÖkoIndex, which considers environmental impacts of materials, including carbon. Buildings exceeding ÖkoIndex level 3 are eligible for an additional grant of 150 €/m2. Materials deemed harmful to climate are prohibited from projects receiving grants. The maximum size of a project that grants cover is 110 m2 and the grants are limited to lower income classes, thus they are part of social housing grants. In addition, projects meeting these criteria are eligible for inexpensive loans. In total, six out of nine Austrian states have similar systems. Altogether, over 500 projects have received these grants.

Z2 - EXAMPLE LANGUAGE

For a district zoning plan or equivalent, add one of the following requirements:

a. The building frame and facade must be predominantly wood.
b. Buildings must have a wooden structure. The facade material must be wood.
c. Buildings must have a wooden structure and façade. The wood elements must be possible to disassemble and reuse in other buildings. The wood elements must be installed using reversible connections and other materials may not be attached to the wood using adhesives, and their reuse may not be otherwise impeded.
d. Buildings must incorporate at least 50 kg of sustainably sourced wood (FSC or PEFC certified), or other bio-sourced material per square meter (in imperial units, 10 pounds per square foot).
e. Buildings must incorporate at least 100 kg CO2e of biogenic carbon storage in permanently installed building structures and materials.

Z3 CARBON-SCORED LAND SALES COMPETITIONS

REDEFINE THE SOLUTION

LAND USE & ZONING

CARBON IMPACT	●●●●○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●○○	ENFORCEABILITY	●●●●○

SUMMARY

When a city is selling land or granting long term leases on a competitive basis, it can apply life-cycle carbon (comprising materials and energy) efficiency of the proposed project as a scoring factor to the bids with a 30 % weighing, or another significant weighing as appropriate. Bidders must calculate and declare the carbon impact of their proposal.

VARIANTS

Winning bid could apply for rezoning permission or waiver if they demonstrate further reducing carbon impact of proposed project by at least 10 % by rezoning or waivers from requirements in the competition program or municipal regulations.

BENEFITS

Carbon performance becomes a built-in feature of projects, as developers compete on concepts achieving higher measured carbon efficiency. Developers commission architects and designers to work on carbon performance in the critical concept phase.
This policy lets market to discover the cost-optimal carbon reductions for projects, does not require city to set the limits, and it does not have maximum level.

PRE-REQUISITES

City needs to own enough land or exercises rights to allocate building rights on it.

ENFORCEMENT

Winner must prove achievement with third party verification. The verification can be applied as a condition before awarding the tender as well as on completion. Tender would be rejected for failing the verification, and a financial penalty on completion.

Z3 - SPOTLIGHT: Porvoo and Tampere

City of Porvoo, Finland (2014) a residential plot allowing 20 000 m2 (215,000 sq.ft) construction was sold at a fixed price with 30 % of the score attributed to life-cycle carbon and 70 % to the architecture of the proposal for joint zoning development. City required bidders to calculate project life-cycle carbon impacts based on EN 15978 standard and the GBC Finland methodology. The winner also committed to deliver the as built results on completion (which has also been done). Calculations were verified by an external expert prior awarding the tender. Price of the land was fixed based on an estimate from an external land valuation expert.

This achieved the lowest carbon residential building in Finland at the time. This was demonstrated as the project was also the winner of the lowest carbon multi-family building competition conducted in the previous year.
Other two examples are competitions from the city of Tampere, Finland. In one of the cases a plot was sold for construction of a hotel and life-cycle carbon was used to attribute 10 % of the score for the second phase (qualified bidders) of the competition. In another case, an existing building was sold for reconversion to residential use and life-cycle carbon was used to attribute 10 % of the score. Both projects achieved significant life-cycle carbon savings, 25 % and 30 %, respectively.

Z3 - ACTUAL LANGUAGE: Porvoo/Finland

Synthetized and translated from the tender for land sales and zoning cooperation document for Porvoon Länsiranta, Aleksanterinkaaren sisäkehä issued by the city:

Tender is evaluated on quality. Quality shall consist of overall quality (70 %) and environmental quality (30 %). Environmental quality is assessed by the life-cycle carbon footprint of the submission, with lower score being preferable.

Tender submissions will be evaluated for environmental quality based on 1. Regulatory energy calculation, 2. Life-cycle carbon footprint, 3. Written description of solutions used to achieve energy and carbon efficiency.

Life-cycle carbon footprint is calculated with One Click LCA software provided by the city of Porvoo to the participants. Participants must submit a life-cycle carbon footprint report as an attachment to the tender.

Calculation guidance to the participants:
Participants must create user account at www.oneclicklca.com and notify support@bionova.fi that they are participating in Aleksanterinkaari competition. They shall get detailed guidance document by reply. Life-cycle carbon footprint must be calculated for 50 years using EN 15978 compliant methodology. The energy supply for the project must consider biogenic fuel share for the Porvoo district heating. Participants may ask for further help from support@bionova.fi.

Written description of the solutions: Competitors ability to achieve stated results are also evaluated in light of retained solutions. A succinct summary of solutions making the project energy and low carbon shall be provided. It must include heating, HVAC and heat recovery and lighting systems.

City may request for clarifications. Omitting to answer to such requests in timely or complete manner may lead to submission being rejected. Described solutions shall be transposed for applicable parts to the land sales contract.

Other two examples are competitions from the city of Tampere, Finland. In one of the cases a plot was sold for construction of a hotel and life-cycle carbon was used to attribute 10 % of the score for the second phase (qualified bidders) of the competition. In another case, an existing building was sold for reconversion to residential use and life-cycle carbon was used to attribute 10 % of the score. Both projects achieved significant life-cycle carbon savings, 25 % and 30 %, respectively.

Z4 PARKING REQUIREMENT OPTIMIZATION

REDUCE & REPLACE MATERIALS AND STRUCTURES

LAND USE & ZONING, REGULATION / SUPERVISION

CARBON IMPACT ●●●○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●●●

ENFORCEABILITY ●●●●●

SUMMARY

Review minimum requirement of city parking capacity in zoning and reduce minimum requirements or move to a market-based mechanism for parking place capacity. Market-based construction allows market to price the need for parking places and deliver matching capacity. This saves a significant share of construction costs for parking infrastructure and avoids stranded assets. Parking capacity maximum can be implemented as a supporting measure as required.

VARIANTS

In addition of totally free market, several market-enabling options exist. They include:

- Each building determines the number of parking places to build. A plot in the district is reserved for a centralized parking building, which is built only if it has enough market demand within 5 years. Otherwise that plot is rezoned.
- Centralized parking building plot is auctioned first. Winner of that plot issues the prices to sell or lease parking places. Other plots submit their tenders with and without central parking. Projects decide how many places they build and buy. If insufficient places are sold, the central building is not built.
- No parking requirement for individual houses, but requirement to join a district parking company. Parking company is zoned land to build parking places for the entire district. All houses decide how many plots they lease. Houses may also build their own parking places.
- Planning requirement to build a minimum number of parking places via a centralized parking company, to which all houses must join or have contract with.

Allowing applying for waivers for minimum parking place reduction when places would have to be built under ground in demanding soil conditions

BENEFITS

Building car parking places is costly, especially underground and in parking towers. In the US, average cost of an underground parking space is estimated at $34,000. In the Nordics, single floor car deck per place costs start from 15 000 EUR and can be up to 65 000 EUR for deep underground places. Reducing these is very attractive for developers, while also avoiding assets which may become stranded if transport system becomes less car ownership dependent.

PRE-REQUISITES

-

ENFORCEMENT

Reducing parking place minimum requirements will not require any additional enforcement as less places save projects money. This policy is very financially attractive that it can be used to balance introduction of other, more onerous policies.

Z4 - SPOTLIGHT: Helsinki, London and several North American cities

City of Helsinki, Finland is presently moving to market-based parking requirements.

Greater London Authority, UK, has maximum residential and retail parking standards and minimum cycle parking standards in London Plan, further described in this article.

Many North American cities are reducing minimum parking standards for districts or the whole city. Some of them are collected in an online map from Strong Towns.

Z4 - ACTUAL LANGUAGE: Portland, Oregon/US

City of Portland, Oregon Title 33, Planning and Zoning, Parking, Loading, And Transportation and Parking Demand Management, Chapter 33.266:

a. Household living uses. The minimum number of required parking spaces for a site with Household Living use is:
(1) Where there are up to 30 dwelling units on the site, no parking is required;
(2) Where there are 31 to 40 dwelling units on the site, the minimum number of required parking spaces is 0.20 spaces per dwelling unit;
(3) Where there are 41 to 50 dwelling units on the site, the minimum number
of required parking spaces is 0.25 spaces per dwelling unit; and
(4) Where there are 51 or more dwelling units on the site, the minimum number of required parking spaces is 0.33 spaces per dwelling unit.

b. All other uses. No parking is required for all other uses.

Z5 APARTMENT SIZE AND SPACE EFFICIENCY GUIDELINES

REDEFINE THE SOLUTION

LAND USE & ZONING, REGULATION / SUPERVISION

CARBON IMPACT ●●●○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●●●

ENFORCEABILITY ●●●●●

SUMMARY

The bigger apartments and buildings are, the higher the resulting carbon emissions will be. Minimum sizes for apartments are commonly regulated by cities for some categories, for example for social housing. Reducing or waiving the minimum space requirements for some categories of apartments can allow reduction of embodied carbon. These requirements could be also incorporated with requirements of minimum built-in storage and sizes of rooms. This needs to be balanced with the space and housing needs of the citizens.

VARIANTS

Zoning laws typically also specify which of the common areas, such as lobby, corridors, elevator areas, shared facilities, storages, technical spaces etc. must be counted towards allowable building area and which may be excluded. Share of common areas and ancillary spaces can be up to 20-30 % of building area. Sometimes storage space is also counted only for a portion towards building areas.

The mechanism that is used to calculate such common and ancillary spaces will lead to variable space design efficiency. For example, when technical spaces are excluded from the allowed building area, they are more likely to be inside the building, whereas in other cases they would more likely be on the roof. Similarly, common areas not counting towards maximum are less efficiently designed.

BENEFITS

Reducing minimum sizes of apartments allows delivering more homes with same amount of construction. This is reducing cost for residents and builders.

PRE-REQUISITES

-

ENFORCEMENT

Reducing apartment size minimum requirements will not require any additional enforcement as it saves projects and residents money. This policy is so financially attractive that it can be used to balance introduction of other more onerous policies.

Z5 - SPOTLIGHT: New York

Previously NYC had minimum apartment sizes in the zoning code. Buildings developed under Quality Housing Regulations had a minimum apartment size of 400 square feet (37 m2). This requirement was removed in 2016, allowing micro units under 400 square feet. For market rate buildings there is no general minimum unit size, but the units must fulfill all other code requirements. Minimum unit sizes apply for affordable housing, affordable senior housing and certain zoning districts.

The NYC Building Code still requires all apartments or dwelling units to have at least one room with a minimum size of 150 square feet (14 m2). This does not include closets, bathroom or a kitchen / kitchenette, which are needed in addition.

Z5 - EXAMPLE LANGUAGE

Building code area definition and space efficiency guidelines to be updated as follows:

All built-in wardrobes and storage spaces that have a minimum of 1,5 meters (5 feet) floor to ceiling height count for 100 % towards the building floor area.

All common areas, including lobby, corridors, elevator areas, designated storage areas and facilities, including technical spaces count for 100 % towards the maximum allowed building floor area.

To allow for incorporating all common areas in the maximum allowed building floor area, the available maximum allowed building floor area is calculated as 125 % of the area given in the zoning regulation for the plot. This allows any building with more efficiently designed common areas to build more residential space instead.

Z6 PREFABRICATED OR MODULAR CONSTRUCTION PRIORITY

REDUCE/REPLACE

LAND USE & ZONING, MUNICIPAL BUILDINGS

CARBON IMPACT ●●●○○

IMPLEMENTABILITY ●●●○○

COST-EFFICIENCY ●●●●○

ENFORCEABILITY ●●●●○

SUMMARY

Provide priority for specific types of buildings that have limited lifespans within a district or zoning area to be built only as modular or prefabricated. This policy would be attached with supplementary requirements on disassembly, adaptation and transport capability for these buildings. This should affect only specified building types. Both modular and prefabricated buildings have higher reuse potential than built in place buildings. This policy is particularly important for buildings whose demand fluctuates based on demographic change at shorter cycles or other changes. On the other hand, this policy is counter-productive for building types that have a predictable long-term need.

VARIANTS

Modular construction could be a compliance path for design for disassembly. It's worth noting that modular systems are sized for general application and therefore they may use significantly more material than a building designed and built for a specific need for a specific site. This is recommended to be arbitered based on the expected building life-span – modular building is a better choice for a short-term use.

BENEFITS

Modular and prefabricated buildings generate much less material waste during construction phase. They also allow the building elements or modules be disassembled once the building is no longer needed in that location and be used in another project, avoiding landfilling and treatment as well as demand for virgin raw materials and construction products.

PRE-REQUISITES

City must have a zoning policy that covers types of materials that can be used.

ENFORCEMENT

This bases on general enforcement of zoning by-laws. Planning permission applications would have to demonstrate compliance with zoning by-laws.

Z6 - EXAMPLE LANGUAGE

For a district zoning plan or equivalent, apply following requirements: All school and daycare buildings (vary building types as necessary) of 200 m2 (2000 sqft) or larger must be built using modular or prefabricated solutions. The projects must demonstrate readiness for the buildings to be able to be deconstructed at the end of their productive life and be transported and rebuilt at another location.

Z7 INCREASING DENSITY USING EXISTING INFRASTRUCTURE

REFURBISH EXISTING ASSETS 

LAND USE & ZONING 

 CARBON IMPACT ●●○○○

 IMPLEMENTABILITY ●●●●○

 COST-EFFICIENCY ●●●●○

 ENFORCEABILITY ●●●●○

SUMMARY

Transport, water, energy and other infrastructure already in place can often be upgraded at less cost and carbon to increase capacity than building infrastructure for new areas. Such upgrades may allow increased density within the affected districts. This policy can rezone existing plots for a density increase. Re-zoning single family home / detached housing plots for more dense forms of construction can increase utilization of infrastructure significantly.

VARIANTS

If a district has a building stock in good condition and this policy could lead to excess demolition, the rezoning requirements could be written so that they specifically allow increasing size of the buildings on the plot if this is achieved by extending existing buildings.

BENEFITS

Increasing capacity of existing infrastructure is more capital efficient than new infrastructure. This may be done at the most economical manner when the infrastructure requires upgrade or significant renovation. Increasing zoning density may provide for revenue streams for doing so either via new council taxes, zoning fees or utility revenues. Additionally, higher density may support higher use of public transport services.

PRE-REQUISITES

This relies on municipal zoning authority.

ENFORCEMENT

Enforcement relies on the city's general ability to enforce zoning by-laws.

Z7 - SPOTLIGHT: State of Oregon

The state of Oregon (U.S.) is working to increase residential density by legislation. Existing legislation requires zoning to allow duplex and quadruplex residential units around single shared yard instead of single-family houses.

Another proposed Oregon bill would set a floor on residential density near priority public transportation corridors – the closer to the transport, the higher the required minimum residential density should be. The summary of the Senate bill 10/2019 is as follows:
"Within areas zoned to allow residential development, cities within the metropolitan service district may not impose a maximum density limit within their urban growth boundary that is less than: (a) 75 residential units per acre if within one-quarter mile of a priority transportation corridor, and (b) 45 residential units per acre if within one-half mile of a priority transportation corridor. Priority transportation corridor includes rail transport, bus rapid transit lines and bus routes with service every 15 minutes or less during peak commuting hours."

Z7 - EXAMPLE LANGUAGE

All plots zoned for residential development in proximity of priority public transport service shall have maximum residential density conditionally increased to new limits. This shall not reduce density on any plots having already a higher residential density.

To be eligible for an increase of residential density, a developer must submit a planning permission application demonstrating that the plot is within the defined maximum distances from priority public transport service as defined by the city, and

a. The increase in residential density can be achieved without demolishing existing buildings; or
b. The project to increase residential density can meet sustainability criteria defined by the city for density increasing projects.

For single-family or detached housing residential plots within 400 meters (one quarter of a mile) of priority public transport service, new residential density maximum shall be [xx] residential units per acre/square meter.

For single-family or detached housing residential plots within 800 meters (half a mile) of priority public transport service, new residential density maximum shall be [xx] residential units per acre/square meter.

For multi-family residential plots within 400 meters (one quarter of a mile) of priority public transport service, new residential density maximum shall be [xx] residential units per acre/square meter.

For multi-family residential plots within 800 meters (half a mile) of priority public transport service, new residential density maximum shall be [xx] residential units per acre/square meter.

The applicant shall state the height of the proposed project in the planning permission application. The city may restrict the permitted height of the construction in the permit to no more than [x] stories / meters / feet higher than prevailing construction in the vicinity of the plot subject to planning permission.

Granted extensions to residential density shall be subject to paying applicable zoning and land use fees as per city policy. Granted extensions to residential density shall not be subject to extensions in minimum parking requirements.

Similar policy could also be implemented for a specified subset of districts.

Z8 USE LOW CARBON BUILDING TYPOLOGIES IN ZONING

REDUCE & REPLACE MATERIALS AND STRUCTURES

LAND USE & ZONING

CARBON IMPACT	●●○○○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●○○	ENFORCEABILITY	●●●●●

SUMMARY

Building typology and massing influence embodied carbon: for example, extremely tall buildings require greater quantities of structural materials that are generally high in embodied carbon. Also, buildings with inefficient massing also require greater quantities of material. Through zoning regulations, a jurisdiction with zoning authority can require building heights to be within an identified carbon-optimal range, and enforce prescriptive requirements for building typology and massing. Similar to the ways zoning laws are used to set requirements for building setbacks, heights, use, and typology. Any policy of this type needs to be designed in a way to that is does not result into urban sprawl, that can lead into far higher infrastructure construction.

VARIANTS

This policy should consider exceptions for very long-lived buildings, such as monumental buildings (opera, major theater or museum, any towers and comparable), for which the requirement should be applied in form of requiring design them for a service life spanning at least a century. This could be determined by building size and building type.

BENEFITS

Zoning allows jurisdictions to enforce prescriptive requirements over large sections of the city, affecting a significant portion of new construction.

PRE-REQUISITES

The jurisdiction must have authority to set and enforce zoning regulations.

ENFORCEMENT

This policy would be enforced through existing zoning enforcement structures, so it would not require additional resources or new systems for enforcement.

Z8 - EXAMPLE LANGUAGE

Policy language for new zoning regulations with a focus on embodied carbon can be adapted from existing zoning regulations. A zoning regulation setting a range for building heights / density could follow the template below.

Intent: It is the intent of these height regulations to reduce the embodied carbon intensity of buildings by constraining heights / density to a range shown to be low carbon.

Requirements: All new non-exempt buildings in a zone subject to this regulation must be between [x.x] and [x.x] feet/meter in height or meet prescribed density criteria.

Exemptions: No building outside of the specified range of height above grade shall be erected without written exemption and certification that the building meets at least one [1] of the following requirements for exemption:

- Is an exempted space type [determine space types that, due to specific structural needs or use purposes, may be exempted]
- Embodied carbon reduction of [xx%] or more against an established baseline, per square foot, square meter, or dwelling unit, for comparable building types
- Demonstrates that is designed for zero waste at the end of its life cycle, with all components able to be disassembled and reused or recycled

Demonstrate a clear project-specific need for construction outside of the allowable height range


BUILDING REGULATION HAS A DETERMINING IMPACT ON NEW CONSTRUCTION
Jonas Ferlin

9. BUILDING REGULATION AND SUPERVISION

R1 LIFE-CYCLE CARBON LIMITS FOR NEW BUILDINGS

REDUCE & REPLACE MATERIALS AND STRUCTURES

REGULATION, MUNICIPAL BUILDINGS

CARBON IMPACT	●●●●●	IMPLEMENTABILITY	●●●○○
COST-EFFICIENCY	●●●○○	ENFORCEABILITY	●●●○○

SUMMARY

Set limits on the maximum life-cycle carbon that new buildings can emit during their defined lifetime. This can be for whole life-cycle carbon (including operational carbon) or embodied carbon.

VARIANTS

Alternatively, these limits could be defined as emissions per year, as long as any differences to standard building assessment periods can be justified with actual structural design dimensioning. The requirement can have default values that can be used for calculation of foundations. Default values for foundations allow projects to be built on zoned plots with poor quality soil, which may be essential to protect property rights of landowners who invested in land prior introduction of regulations.

BENEFITS

Having a hard target as a requirement ensures that developers and investors set those targets in their design briefs to designers. This in turn ensures that designers start working towards those targets from the early design, thus avoiding high carbon solutions and identifying carbon reducing opportunities as part of the design process.

PRE-REQUISITES

A carbon accounting methodology that is available and recognized on the market. For markets with national methodology, those are used in priority. For all of EU / EEA and number of other countries, the European Standards based methods can be applied. For other markets the ISO standard based methods can be used. However, ISO standards rarely have an official status

ENFORCEMENT

This type of requirement can be issued if city has regulatory powers. Alternatively, cities may impose the requirement via land sales agreements. Enforcement will require an ability to review and audit the calculations, and applying a penalty for misreporting project carbon performance or deviating from plans in construction.

R1 - SPOTLIGHT: Vincent, Douro-Dummer, London

The City of Vincent (Australia) Planning and Building Policy Manual, policy number 7.1.1., Built Form, requires for City Centre developments that they:

Achieve Green Building Council of Australia's 5-star Green Star rating or
using ISO 14044 "Environmental management – Life cycle assessment – Requirements and Guidelines" and EN15978 "Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method."
Residential component:
- The Global warming potential of the development over its lifetime is to be reduced by 50% or more when compared to the average Australian code-compliant equivalent building built at the same time.
Commercial component:
- The Global warming potential of the development over its lifetime is to be reduced by 30% or more when compared to the average Australian code-compliant equivalent building built at the same time.

The township of Douro-Dummer (Ontario, Canada), Sustainable Development Guidelines 2020 provides 50 first applicants (after March 1st 2020) an opportunity to apply for a block grant for projects whose carbon emissions are below the fixed target. The planned program outline is to reward builders with a grant of $10,000 (Canadian dollars) per house that meets the requirements. As the grant application is not open yet, the final threshold values are not yet set. The construction will be measured in accordance with defined criteria and the associated Carbon Calculator from Builders for Climate Action. The up-front carbon emissions of the buildings are divided by eligible floor area. Foreseen cap is to be 75 kgCO2e/m2. There will be additional requirements for building operational performance as well.

London's borough of Camden (UK) includes in the Local Plan 2017 has a soft requirement:
8.20 As part of the assessment of resource efficiency, all developments involving five or more dwellings and/or more than 500 sqm gross internal floor space are encouraged to assess the embodied carbon emissions associated with the development within the energy and sustainability statement. Where such an assessment has been completed, we would encourage that the results are logged on the RICS whole life Building Carbon Database in order to contribute to the embodied carbon knowledge base.

R1 - EXAMPLE LANGUAGE

All projects applying for planning permission shall calculate life-cycle carbon footprint of the proposed development using the following methodology: *Ministry of Environment, Finland (August 2019) / Whole life carbon assessment for the built environment, RICS (November 2017) / NS 3720:2018 Metode for klimagassberegninger for bygninger / European Standard EN 15978*.

Where national methodology does not provide more detailed guidance, the calculation shall cover:

- Operational energy as per applicable building regulations, matching the calculated and reported energy performance calculation, using the energy emission factors issued in the national methodology.
- Construction materials for sub- and superstructure, building envelope, foundations and parking structures, omitting finishes and services.
- A calculation period of 60 years.
- The minimum required life-cycle modules are A1-A3 Construction materials, B4-B5 Replacement of materials in use, B6 Operational Energy, and C1-C4 End of life. The calculation shall not include the end of life benefits (D).
- The calculation shall be reported per building area using the *heated net area / Gross Internal Floor Area / Bruttoareal* as denominator.

Projects shall demonstrate a minimum life-cycle carbon reduction of 40 % from the *national reference building / national carbon reference values / standard building life-cycle carbon impacts*. A standard building shall be using same shape as actual building, meeting regulatory energy performance and use the most common materials for the specified building type.

Projects can use any tools of their choosing that are shown by compliance certification or other reliable means to be in compliance with the methodology.

To demonstrate compliance, projects shall submit a carbon calculation report in line with the required methodology as well as the bill of materials and energy used for the calculation to allow a verification of the calculation plausibility.

City reserves the right to audit submitted data for plausibility, both at the time of application and at time of completion. City may request for updated calculations at the completion time as well as clarifications at any time. Omitting to answer to such requests in timely or complete manner may lead to application being rejected.

The applicant is required to implement the project to the carbon performance standard stated in the application. Exceeding initially calculated performance shall subject the project to an administrative penalty of 150 EUR / m2 ($15.6 /sq.ft).

Failure to submit the documentation required or provide required clarifications will lead to permit being denied, or at the city's discretion, an administrative penalty of 150 EUR / m2 ($15.6 /sq.ft).

R2 LOW CARBON CEMENT AND CONCRETE POLICY

REQUIRE LOW CARBON PRODUCTS

REGULATION, PROCUREMENT, MUNICIPAL BUILDINGS, INFRASTRUCTURE

CARBON IMPACT	●●●●●	**IMPLEMENTABILITY**	●●○○○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●○○

SUMMARY

Implement a comprehensive low carbon cement and concrete policy that shall:

- Permit performance-based concrete requirements to be always used
- Replace water to cement ratios with durability and shrinkage requirements, eliminating non-performance-based requirements that lead to increased use of cement
- Set maximum carbon performance limits for concrete by strength classes

Encourage applying strength evaluation time at 90d not 28d to enable broader use of secondary binders (e.g. fly ash or blast furnace slag).

VARIANTS

Set maximum carbon performance limits for cements, including allowing alternative cement types such as IL, II, III, IV, or V types, and blended cements that reduce carbon impacts of construction. It's worth noting that for precast concrete, using heat for speeding up strength development may allow reducing total use of cement in meaningful quantities. Inversely, using ready-mix concrete in cold temperatures may require heating. Further provisions for soil stabilization should be provided in low carbon sites policy (see *M6 Low Carbon Sites, Stabilization and Foundations*).

BENEFITS

Cement and concrete are essential construction materials that are used in very significant quantities. Due to cement manufacturing emissions and the sheer volume of use, they also have a high climate impact. Targeting cement and concrete with performance-based carbon requirements helps improve these products across the board in all construction which is subject to specified requirements.

PRE-REQUISITES

No pre-requisites have been identified for the construction that is purchased by the city, but extending the scheme to the private sector construction requires that a city possess regulatory powers.

ENFORCEMENT

Reduction in the amount of cement used in concrete manufacturing has potential to reduce cost or at least remain cost neutral. Verification would need to be based on commercial documents for demonstrating origin as well as on Environmental Product Declarations for demonstrating carbon performance of the purchased products.

R2 - SPOTLIGHT: Singapore, Norway, Marin County, Portland

The Singapore Building and Construction Authority operates a green building scheme called BCA Greenmark. The scheme provides additional construction rights for them who achieve a good score, a valuable incentive in a country with limited land. BCA Green Mark awards points from using alternative binders in concrete. They start from 5 % of ordinary portland cement substitution with either ground granulated blastfurnace slag, fly ash or silica fume. Further 20 % substitution gets maximum points available under this scheme.

Norsk Betongforening (Norwegian Concrete Association) enforced a low carbon concrete standard in 2015. It was revised to be more stringent in 2019. The standard defines for each compressive strength class of concrete four low carbon classes. These are called Low Carbon A, Low Carbon B, Low Carbon Plus and Low Carbon Extreme. In the 2015 edition of the standards, market generally required Low Carbon B level. The standard is available to buy and only in Norwegian language. It is widely adopted by both public and private sectors in Norway and has changed the marketplace. It is worth noting that in cold climates and seasons cement substitutes either need additional heating, longer hardening times, or both to achieve targeted strength.

Marin County in California has implemented a Low Carbon Concrete Code, which provides a Cement limit and an Embodied Carbon limit pathway. For each specified compressive strength, a maximum amount of ordinary Portland cement and a maximum embodied carbon are defined. Embodied carbon is shown by an Environmental Product Declaration in line with ISO 14025, and EN 15804 or ISO 21930.

Portland, Oregon has introduced requirements for concrete in municipal procurement which require product-specific and third-party verified EPD for products from January 2020. City will then publish maximum acceptable Global Warming Potentials for concrete in 2021, and start requiring all products purchased by the city to demonstrate with EPDs that they are not exceeding required threshold values for the specific concrete strength class in question.

Further local requirements have been set by Masdar City and Dubai.

R2 - EXAMPLE LANGUAGE

For all public works funded or co-funded by the city, design and procurement of concrete shall not set prescriptive requirements for water to cement ratios or minimum quantity of cement or types of cement to use. Instead, all requirements shall be expressed as performance-based requirements.

For all public works funded or co-funded by the city, design, procurement and supply of concrete either by or on behalf of the city for city projects shall be subject to the following requirements:

1. For each concrete strength class used, the highest allowed embodied carbon emissions from the raw materials and supply of the concrete for scope A1-A3 as defined in EN 15804 / ISO 21930 is not higher than 80 % of the cement embodied carbon if the compressive strength is achieved by pure ordinary Portland cement whose embodied carbon impact is 1 kg CO_2e / kg cement. Example: for concrete strength class normally requiring 320 kg of cement per cubic meter, the highest allowable embodied carbon impact shall be (320 kg x 1 kg CO_2e / kg x 0,8) = 256 kg CO_2e / m3.
2. Projects are required to achieve same technical and functional performance characteristics as stipulated in the tender and other documents.
3. Designers and construction planners are required to plan concrete compressive strength evaluation times based on project critical path need. Strength evaluation time shall be 90d or 60d, where early strength development is not required. This allows higher ratios of secondary binders.
4. Projects using less than 50 cubic meters of concrete may apply for a waiver from these requirements.

5. Projects are allowed to deviate from these requirements for a maximum of 5 % of total volume of the concrete used. All deviations must be documented and reason for deviation be justified and reported.
6. Projects may seek an advance written waiver for deviations exceeding 5 % for reasons including pouring in particularly cold conditions, high exposure class or salinity conditions, cases where early strength development is critical or other cases making these requirements unfeasible. For any waiver request, the project must state quantities concerned and reasons for not being able to use low carbon concrete.
7. Acceptable methods to demonstrate concrete compliance with these requirements are
    a. A company and product specific Environmental Product Declaration prepared in compliance with ISO 14025 and EN 15804/ISO 21930 which must not be expired at point of specification. The EPD shall either be able to demonstrate a variability no higher than 10 % or be plant-specific to the plant supplying the concrete.
    b. A cement content that is at least 30 % below the cement content the concrete strength class would normally require.
8. Concrete performance data shall be recorded and submitted as part of the compliance documentation.

Similar requirements can be applied to the private sector construction.

Above requirement could be made more powerful by extending the scope to cover transport to construction site (Life cycle stage A4).

R3 MATERIAL-EFFICIENT STRUCTURAL DESIGN REQUIREMENT

REDUCE & REPLACE MATERIALS AND STRUCTURES

REGULATION, PROCUREMENT, MUNICIPAL BUILDINGS, INFRASTRUCTURE

CARBON IMPACT	●●●●○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●●●	**ENFORCEABILITY**	●●●○○

SUMMARY

Structural materials are some of the most significant sources of embodied carbon because of the large volumes used. Current practice often uses excess material, creating significant opportunities for embodied carbon reductions within the structure. Current digital design tools make the optimization of materials feasible to much greater levels than has been previously possible. A requirement for encouraging more efficient use of structures and structural materials would allow buildings to become more material efficient. This is a necessary precondition for lower embodied carbon buildings. At the same time, building longevity, especially for larger buildings, should be considered. These should be designed for at least 100-year lifetime to avoid early demolition.

VARIANTS

See next page.

BENEFITS

Industry has over one hundred years tradition designing above minimum requirements. While this could save significantly in costs, efficiencies are not pursued on market basis today. Current practice of office buildings with average age of six years in London shows for above ground office floor an imposed floor loading of 4.5 kN/m2. However, the regulations (Eurocodes, EN 1991-1-1) and recommendations (BCO Specification for Offices) respectively suggest office area loading of between 2.0kN/m2 and 3.0kN/m2, and 2.5kN/m2. This suggests structural design 80 % above the code's requirements. This type of materials use is in fact in line with regulations in place in the City of London in 1909, at a time when detailed modeling of building structures was not possible. Similarly, current practice in Dublin is 4.0kN/m2, being 60 % above code's requirements. Additionally, examples from US cities show that best in class structural designs can use 45% less material than standard designs. Obviously, there are conditions where future adaptability and the use of the higher loading is warranted, but above demonstrates prevalence of over-engineering.

PRE-REQUISITES

Ability to write and enforce a building code, or achieve similar result by contractual means.

ENFORCEMENT

Currently building supervision inspects structural designs and loading plans to ensure life safety and compliance with minimum code requirements. These same inspections could also confirm that the design is not wildly over-engineered. However, considering the level of specialization and available resources within the departments, a peer review among structural designers could be a solution. This could help achieve both building design safety and materials optimization.

R3 – VARIANTS

Material inefficiency arises from several sources, including architectural building layouts that don't maintain efficient load paths, a risk mitigation and/or lack of optimization by the engineer that sometimes go beyond building code or owner or contractor prioritization of simpler, but more carbon intensive construction practice.

Structural regulations are life-safety regulations, and as such, policies in this area need to be considered to not compromise life safety. However, as much is possible without that compromise, this type of regulation is best implemented as combination of structural mass and structural efficiency as well as their disclosure and inclusion of resulting data to a benchmark database. This allows accumulation of benchmark data for measuring and comparing projects. This dataset allows an interim solution of encouraging competition by data disclosure and comparison of actual materials efficiency, which also is a direct cost driver for investors. Thus, fostered competition could then drive some of the parties to increase efficiency.

Considering establishing baselines for these requires a lot of data accumulation. An interim solution to use could be Utilization Ratio to describe structural design efficiency could be introduced while requiring disclosure of materials use. This type of policy can also be introduced as a basis for an incentive being granted.

For more impact this could be also extend to cover facades and external walls (shell and core). For example, a lightweight façade with superior thermal barrier values can save a lot of structural material, especially in in high seismic zones. Wood buildings could be exempted from some requirements as even inefficiently designed wood structures are lighter and use less material.

Another approach to this could be reporting the embodied carbon footprint per unit of gross built floor area of project. If amortized over a 100-year lifetime, including an allowance for embodied carbon credits for buildings conceived to last even more than 100 years, a reporting and disclosure policy could be introduced. This could also be used as a basis for specified incentives, if coupled with third party verification of the underlying life-cycle assessment or embodied carbon report.

R3 - SPOTLIGHT: Singapore, UK and US

The Singapore Building and Construction Authority operates a green building scheme called BCA Green Mark. The scheme provides additional construction for them who achieve a good score, a valuable incentive in a country with limited land. BCA Green Mark awards points from using concrete more efficiently. The best in class concrete target is using less than 840 kg concrete/m^2, and points are still possible while using no more than double of that. This includes all the concrete, also in foundations and underground car parks. This is a good example of policy implementation in a city that does not have a history of placing priority on engineering optimization.

Optimization initiatives have also recently been launched by the Institution of Structural Engineers (UK), as well as the US Structural Engineering Institute (SEI) 2050 Challenge. Both initiatives encourage members to:

- Design to code but without over-capacity ("enough …. and no more")
- Develop performance-based design approaches into project designs

Mandated structural peer review processes are adopted in highly seismic zones of the West Coast of the United States. These types of policies have been adopted for example by cities of San Francisco, Los Angeles and Seattle.

R3 - EXAMPLE LANGUAGE

All projects submitting detailed plans as part of a planning application for new buildings or extensions of at least four stories tall, or larger than 1000 m^2 (11,000 square feet) shall be required to deliver a Structural Materials Quantities report and an Average Utilisation Ratio report for the whole project, where the latter must demonstrate no more than 40 % overcapacity (50 % in highly seismic regions). The allowable overcapacity is planned to be reduced further in revisions of these requirements, while priority being given to reduction of total materials use in the entire building*.

Further, all projects at least ten stories tall or larger than 10000 m2 (110,000 square feet) shall be required to deliver a peer review of the structural design to inspect the appropriateness of the project for code compliance, as well as system and material efficiency and conformity with the overcapacity requirement above. For purposes of structural design, all buildings of this size category shall be designed for a minimum 100-year design life.

Utilisation Ratio is defined as the ratio between an actual performance value and the maximum allowable performance value which is deemed limiting for a structural member. The Average Utilisation Ratio is calculated by area-weighted averages of Utilisation Ratios of the building.

The Structural Materials Quantities report shall provide as background information project building type classification, project gross floor area, project height, number of above ground and underground floors. The report details the quantities for structural materials used in all structures (under or above ground) for:

1. Concrete, in metric tons and as kg per gross floor area
2. Reinforcement steel, in metric tons and as kg per gross floor area
3. Structural steel, in metric tons and as kg per gross floor area
4. Timber, in metric tons and as kg per gross floor area

Using the provided data, City shall publish Structural Materials Quantities Benchmarks for building types and for ranges of stories. The City may implement future regulations using created benchmarks or use them as a basis for incentives.

Additionally, projects need to file a full building Life Cycle Analysis (LCA) evaluation at design completion but prior to construction. And as a condition of receiving a certificate of occupancy, the project shall also report final as-built structural materials quantities, and updated LCA reporting the final structural masses.

** In some cases, designer may choose to change the geometry of the load path resulting into lower utilization ratio on certain members, but with an effect that reduces the overall project material consumption. Therefore, as sole lever, the Utilisation Ratio is not sufficient.*

R4 DENSITY BONUS FOR CARBON EFFICIENCY

REDEFINE THE SOLUTION

FINANCIAL POLICIES, BUILDING REGULATIONS

CARBON IMPACT	●●●○○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●●●	ENFORCEABILITY	●●●●○

SUMMARY

Projects that meet the embodied carbon criteria are eligible for density bonuses in the form of right to build additional units or increased floor-area ratio.

VARIANTS

If existing density bonus incentives exist for affordable housing or sustainable design, the embodied carbon criteria may be added as a pathway.

BENEFITS

In many markets, added density is a significant financial benefit to developers. This incentive will result in more widespread and faster adoption of low-embodied carbon building practices. Density bonuses allow municipalities to offer a meaningful incentive with little or no financial investment, and without adding significant complexity to the permitting process.

PRE-REQUISITES

For density bonuses to be desirable for developers, current density limits must frequently be reached. As significant financial benefit is granted, the system should include the possibility of independent audit.

ENFORCEMENT

This policy would be enforced through existing zoning enforcement structures. Therefore, would not require additional resources or new systems of enforcement.

R4 - SPOTLIGHT: Seattle, Washington, Arlington, France and Ontario

Seattle, Washington and Arlington in State of Virginia have density bonus programs for energy efficiency that do not address embodied carbon, but their general structure and implementation may serve as models.

A French E+C- pilot program allowed cities to increase gross floor area by 15% for life-cycle carbon reductions. Singapore BCA allows a density increase of up to 15% and includes embodied carbon and low carbon cement and concrete requirement.

Province of Ontario's Section 37 permits developers to build beyond existing density restrictions in exchange for "facilities, services, or matters." This has been allowed against cash contributions towards public infrastructure but could clearly be revised to also consider carbon reductions.

R4 - EXAMPLE LANGUAGE

Language for new zoning policies incentivizing embodied carbon reductions can be adapted from existing zoning incentive policies. A zoning incentive offering bonus density beyond existing density limits could follow the template below:

Intent: The intent of the Density Bonus for Carbon Efficiency is to incentivize developers to build low-embodied carbon projects, thereby increasing the number of projects, reducing citywide emissions, and encouraging exemplary projects.

Eligible buildings: Mid- to high-rise multifamily and commercial buildings are eligible, as well as developments with multiple residential units on a single lot.

Requirements: Projects must demonstrate an embodied carbon reduction of [xx%] or more against an established baseline, per area or dwelling, for same building type.

Incentive: Projects that meet the requirements above may be eligible for increases in density above the established limits of [X.X] floor-area ratio or [X] units/dwellings per acre, up to a floor-area ratio of X.X or X units/dwellings per acre.

R5 ZERO CARBON CONSTRUCTION SITES

REQUIRE LOW CARBON PRODUCTS

REGULATION, PROCUREMENT, MUNICIPAL BUILDINGS, INFRASTRUCTURE

CARBON IMPACT	●●○○○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●○○○	ENFORCEABILITY	●●●●○

SUMMARY

Implement a requirement that construction sites end (or reduce) the use of internal combustion engines. This means ending the use of fossil fuels as well as biofuels. This will then leave following options: a) electric battery; b) plug in electric; and c) fuel cell power train. The policy would apply to both building and infrastructure construction sites.

VARIANTS

Where market is evaluated not to be ready to move to electrified construction sites or have a very high emission electrical grid, using biofuels for site machinery can be a relevant option. In such cases biofuels should be required to fulfil applicable fuel norms, for example in case of biodiesel the European diesel norm EN 15940. This policy has no CO2 benefit if local electricity mix is as dirty as fossil fuels themselves.

BENEFITS

Reducing or ending the use of internal combustion engines in construction site machinery also reduces noise and local combustion emissions. It has impact on NOx, SOx and particle emissions.

PRE-REQUISITES

Ability to enact regulations covering construction site activities or machines. For some cities, this may be enabled by authority who regulates the air quality.
Policy can be alternatively enacted as a condition of land sales, purchasing or zoning.

ENFORCEMENT

Site inspection can easily identify non-compliant machines. First generation biodiesel powered machines generally can be identified by smell compared to diesel. A biofuel that is not readily identifiable is biogas, which is very rarely used in machinery.

R5 - SPOTLIGHT: Trondheim, Oslo, Malmö, Göteborg and Stockholm

The City of Trondheim (Norway) environmental policy for municipal buildings requires:

- All site construction machines must be fossil fuel free
- Idling (keeping motors running) is prohibited on the site or in the vicinity of the site
- Machines and equipment shall use electricity as far as possible
- Heating and drying shall use district heat or electricity
- Site buildings energy efficiency must meet TEK17 (building code) requirements and reduce temperature for nights, weekends and holidays
- Lighting on the site shall be energy efficient and used on a needs-driven basis
- Biodiesel must meet EN15940 and national sustainability requirements. Palm oil or palm oil by-products are not allowed.

The City of Oslo's climate and environmental requirements for construction sites are mandatory for all City's construction projects and specify fossil-free construction as a minimum criteria. It also awards zero-emission construction equipment with up to 15% of total competition criteria. However, these only concern construction for the City itself.

The Swedish cities of Malmö, Göteborg and Stockholm and the national transport authority Trafikverket have Common environmental requirements for contractors. These require that 20 % of total energy use in machines and transport devices be delivered via renewable energy sources, including certified renewable electricity or biofuels.
In cases where biofuels are used to meet climate requirements, the fuels used must have a sustainability certificate issued by the Swedish Energy Agency in accordance with the Act on Sustainability Criteria for Biofuels and Bioliquids (2010:598).

Further examples have been documented in a recent report from the Norwegian Bellona on Zero Emission Construction Sites.

R5 - EXAMPLE LANGUAGE

All new construction or building extension projects with total applied construction of at least 300 m^2 (3,300 square feet) and all renovation projects with total applied renovated area of at least 1000 m^2 (10,760 square feet) are prohibited from causing emissions harmful for human health to air from powering stationary and mobile construction site machinery with fossil fuels. All stationary and mobile construction site machinery shall be either electrified, use fuel cells or other zero emissions technology for power.

Construction site machinery includes heavy machinery (including excavators, cranes, bulldozers, piling machines and others) as well as starting from 1 January 2023, light machinery (including air compressors, generators, pumps, heaters and others) as well as starting from 1 January 2023, all stationary construction site equipment, including heaters and site elevators. The regulation does not apply to transport equipment used to transport goods to or from the site.

Construction projects filing a permit application before 31 December 2020 can request for a waiver from this requirement for up to five different types of machinery which shall be stated in the waiver request. Projects filing a permit application before 31 December 2022 can request for a waiver from this requirement for up to three different types of machinery. Types of machinery applying for this waiver must be powered by biofuels, for example biodiesel or biogas on this construction site.

R6 CONSTRUCTION MATERIALS EFFICIENCY DECLARATION

REDUCE & REPLACE MATERIALS AND STRUCTURES

REGULATION, PROCUREMENT, MUNICIPAL BUILDINGS, INFRASTRUCTURE

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●●○	**ENFORCEABILITY**	●●●●○

SUMMARY

Require declaration of key material mass per m^2 / square foot of building to be filed for the planning permit process at the occupancy permit application stage for new buildings and extensions of at least 300 m^2 (3,300 square feet), or as appropriate considering building sizes within the city.

VARIANTS

The policy can be extended to or substituted with earlier stage reporting requirement for larger or all projects. This could have more influence on design.

Another option is to require a materials passport that would provide detailed information about the construction products and how they were installed. This could be used when a renovation or demolition permit is sought to reuse materials.

This policy could also be worked into maximum materials use limits.

BENEFITS

Creating benchmark data on building materials use and making projects/developers aware of them allows identifying cash savings via saving material.
In the US West Coast, a comparison of five similar sized high-rise buildings, all in seismic areas, identified structural material efficiency differences of 1x to 1.8x. In other words, the least efficient building used almost two times as much materials per square feet as the most efficient one. The City can publish similar anonymized statistics about the buildings in the city later to increase investor awareness of why materials efficiency matters in design briefs.

PRE-REQUISITES

Regulatory authority to allow asking for additional information during permitting.

ENFORCEMENT

Enforcement relies on the planning permit process. This policy is creating awareness by making information transparent. This does not require setting limits.

R6 - SPOTLIGHT: Netherlands

Closest to an actual implementation that was identified is the Dutch Platform CB'23's *Leidraad - Paspoorten voor de bouw - Werkafspraken voor een circulaire bouw,* which has been prepared as a materials passport requirement for regulatory application.

R6 - EXAMPLE LANGUAGE

All projects applying for occupancy permit for new buildings or renovations of at least 300 m^2 (3,300 square feet) shall be required to deliver a construction materials efficiency declaration. The declaration shall provide project building type classification, project gross floor area and internal floor area(s), project height, number of above ground and underground floors and following quantity information:

1. ready-mix concrete, in cubic meters (m3)
2. precast concrete elements, in cubic meters (m3)
3. cement, in tons (t)
4. quicklime, in tons (t)
5. bricks, in tons (t)
6. reinforcement steel, excluding quantities in precast elements, in tons (t)
7. structural and other steel, in tons (t)
8. glass, in tons (t)
9. insulation materials (all types), in tons (t)

Gypsum and plasterboards, in tons (t)

R7 EXPEDITED PERMITTING FOR LOW CARBON PROJECTS

REQUIRE LOW CARBON PRODUCTS

BUILDING REGULATION, FINANCIAL POLICIES

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●●●

SUMMARY

Permit applications that meet given embodied carbon criteria shall be given expedited or reduced fee processing. Examples of embodied carbon criteria may include Life Cycle Assessment requirements or other requirements.

VARIANTS

If expedited or reduced fee permitting programs exist for affordable housing, energy efficiency, or similar, achievement of embodied carbon criteria could be added as a pathway or as an additional criteria.

BENEFITS

Lowering the barriers for developers starting or considering low-embodied carbon construction will result in more widespread and faster adoption of low-embodied carbon building practices. Review and permitting process lengths vary from one jurisdiction to another, and in some municipalities the waiting period is a significant burden (regarding cost and/or timeline) for developers. According to USGBC:

"Allowing developers to significantly reduce the duration of this process, in exchange for committing to specific green building standards, can result in significant cost savings for the developer. This allows a municipality to offer a significant incentive with little or no financial investment, since it only requires a shift in permitting priority."

PRE-REQUISITES

The jurisdiction must have permitting authority as well as an authority over permitting processes.

ENFORCEMENT

This policy does not require enforcement for projects participating in the program, but the permitting authority should be accountable and transparent in the timeliness they offer.

R7 - SPOTLIGHT: San Diego and Seattle

The City of San Diego's Sustainable Building Expedited Permitting Program, described in Policy Number 600-27, designates that new residential, commercial and industrial buildings designed to achieve LEED Silver Certification can qualify for expedited permits. The expedited permitting process is estimated to be 25% less time consuming than the normal permitting process.

The City of Seattle's Priority Green Expedited program sets thresholds for energy efficiency, water conservation, waste reduction, and indoor air quality. They then offer building owners who meet the requirements a single point of contact in the Department of Construction & Inspections, priority in scheduling an intake appointment, faster initial review of construction plans and faster permit processing.

R7 - EXAMPLE LANGUAGE

Program language can be adapted from existing expedited or reduced fee permitting programs. In most cases, legislative process and formal policy adoption is not be prerequisite for a city to establish expedited or reduced fee permitting as an internal policy or program. Creation of an expedited or reduced fee permitting program for low-carbon buildings could follow the template below:

Intent: The intent of the Green Lane for Permitting Low Carbon Projects program is to reduce the barriers, cost, and waiting time for developers seeking permit approval for low carbon construction projects.

Eligible buildings: All buildings that are subject to the permitting authority's approval may be eligible.

Requirements: To be placed in the Green Lane, construction plans and models must demonstrate at least one of the following:

- Completion of a whole-building Life Cycle Assessment for the project
- Embodied carbon reduction at least of [xx%] against an established baseline, per square foot, square meter, dwelling unit, for comparable building types

Benefits: Projects channeled to the Green Lane will benefit from [some selection of]:

- An assigned single point of contact within the permitting authority, available to assist with forms, status updates, and requests for information
- Waiver of [X.X%] of permitting fees

Waiting times reduced by an average of [X.X%] or [X] days for each stage of permit review

R8 PROHIBITING EXTREMELY HIGH EMITTING MATERIALS

REQUIRE LOW CARBON PRODUCTS

BUILDING REGULATION

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●○○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●○○○

SUMMARY

This policy prohibits the use of specific building materials associated with extremely high GHG emissions, such as spray foams with hydrofluorocarbon blowing agents used in insulation. It can most often be implemented by local ordinance and may also be implemented by through building code.

VARIANTS

As alternatives to banning the use of extremely high GHG-emitting building materials through ordinance or building code, a jurisdiction could:

- ban the sale or purchase of the identified materials
- require designers or builders to specify defined low/no GHG-emitting alternative materials in order the permit to be approved
- financially penalize the use of high GHG-emitting materials

incentivize the use of low/no GHG-emitting alternative materials

BENEFITS

Banning extremely high GHG-emitting building materials is an impactful way to reduce embodied carbon in new construction and renovation. This can be done without requiring significant changes to the design process or increasing analysis and reporting burdens on designers, builders, developers or building owners.

PRE-REQUISITES

The jurisdiction must have the authority to prohibit building materials if legislation seeks to ban the use or sale of high GHG-emitting materials outright. If the jurisdiction does not have this legal authority the alternative implementation pathways identified above can be explored. This policy is unlikely to be feasible to implement within the European Union.

ENFORCEMENT

Building inspections after new construction or renovation projects must confirm that no prohibited materials have been used before a building is permitted to be occupied.

R8 - EXAMPLE LANGUAGE

Intent: It is the intent of this policy to reduce embodied carbon in new construction and renovation by prohibiting certain materials with disproportionate contributions to embodied carbon emissions, and for which comparatively carbon-efficient alternatives exist.

Requirement: The following materials are not to be sold, purchased or to be used in new construction or renovation projects: [list prohibited materials, such as spray foams with hydrofluorocarbon blowing agents]

Enforcement: Building inspections after new construction or renovation projects must confirm that no prohibited materials have been used before a building is permitted to be occupied. Buildings that have used or purchased prohibited materials will pay a penalty sufficient to offset that difference in embodied carbon emissions. This could be for example a value between the embodied carbon of total amount of prohibited material they have used and the estimated embodied carbon of a practical, non-prohibited alternative. The penalty will be determined by the jurisdiction per weight and what kind of prohibited material was used.

Exemptions: Materials and products that have been reclaimed may be used if their entire embodied carbon footprint is "locked in". Be this it is meant that the embodied carbon is created during manufacturing and not during application or use. The user must provide documentation showing that the materials were used and then salvaged or donated, rather than just passed on by a middleman.

R9 LIFE-CYCLE CARBON CALCULATION AND REPORTING

REDUCE & REPLACE MATERIALS AND STRUCTURES

BUILDING REGULATION

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●○

SUMMARY

Require all projects to calculate and report their life-cycle carbon emissions using a standardized measure, separating embodied and operational carbon.

VARIANTS

The requirement could also be applied only for embodied carbon.

BENEFITS

Having calculation and reporting requirement increases the familiarity with the methodology and paves the way for future regulatory limits as well as collects data that can be used to set a future regulatory limit.

PRE-REQUISITES

A carbon accounting methodology that is available and recognized on the market. For markets with national methodology should be used as priority. For other countries, the European and International Standards based methods could be applied.

ENFORCEMENT

This type of requirement can be issued if city has regulatory powers.

R9 - SPOTLIGHT: London

London Plan 2020 includes a Policy SI 2 Minimizing greenhouse gas emissions, part F:

Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognized Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions. Further guidance is going to be issued but is not yet available.

London borough of Camden (UK) includes in the Local Plan 2017 a soft requirement:

8.20 As part of the assessment of resource efficiency, all developments involving five or more dwellings and/or more than 500 sqm gross internal floor space are encouraged to assess the embodied carbon emissions associated with the development within the energy and sustainability statement. Where such an assessment has been completed, it is encouraged that the results are logged on the WRAP embodied carbon database (now called RICS database) in order to contribute to the embodied carbon knowledge base.

R9 - EXAMPLE LANGUAGE

All projects applying for construction permit shall:

Calculate life-cycle carbon footprint of the proposed development using the following methodology: *Ministry of Environment, Finland (August 2019) / Whole life carbon assessment for the built environment, RICS (November 2017) / NS 3720:2018 Metode for klimagassberegninger for bygninger / European Standard EN 15978.*

Where national methodology does not provide more detailed guidance, the calculation shall cover:

- Operational energy as per applicable building regulations, matching the calculated and reported energy performance calculation and using the energy emission factors issued in the national methodology.
- Construction materials for sub- and superstructure, building envelope, foundations and parking structures, omitting finishes and services.
- A calculation period of 60 years.
- The minimum required life-cycle modules are A1-A3 Construction materials, B4-B5 Replacement of materials in use, B6 Operational Energy, and C1-C4 End of life. The calculation shall not deduce the end of life benefits (D).
- The calculation shall be reported per building area using the *heated net area / Gross Internal Floor Area / Bruttoareal* as denominator.

Projects can use any tools of their choosing that are shown by compliance certification or other reliable means to be in compliance with the methodology.

To demonstrate compliance, projects shall submit a carbon calculation report in line with the required methodology as well as the bill of materials and energy certificate.

Failure to submit the documentation required will lead to permit being denied.

10. PROCUREMENT

P1 CARBON LIMITS FOR BUILDING MATERIALS PROCUREMENT

REQUIRE LOW CARBON PRODUCTS

MUNICIPAL BUILDINGS, INFRASTRUCTURE, PROCUREMENT

CARBON IMPACT	●●●○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●○

SUMMARY

Set carbon intensity limits for key materials for the major construction material groups for all city projects and implement in public procurement. Ensure same requirements are enforceable also for construction projects where the city is buying or long-term leasing the building. These can be demonstrated using Environmental Product Declarations for example. These would be required when a project is bid, and then completed, so that the purchase is verifiable.

VARIANTS

Requirements could include materials transport carbon impacts when practicable. The carbon impact of material transport influences results and may render low carbon products transported from further away to high carbon ones. Alternatively, products could use a low carbon materials label (if suitable one exists).

BENEFITS

Having prescriptive carbon requirements forces the construction supply chain to develop data and products and use it to deliver and specify projects as well as products. It also provides an incentive to develop and document low carbon products.

PRE-REQUISITES

This requires no specific authority, as procurers right to choose normally falls within general contract law. However, implementing the requirement will be clearly harder if the market has no readiness to provide any Environmental Product Declarations.

ENFORCEMENT

Enforcement can be incorporated as part of general contract obligations and enforced using those means.

P1 - SPOTLIGHT: Trondheim, Los Angeles, Norway, France and Belgium

The City of Trondheim (Norway) requires the following from materials procurement:

- Concrete, both ready-mix and elements must meet low carbon class A
- Massive wood carbon limit 70 kg CO2e / m3
- CLT and glulam carbon limit 100 kg CO2e / m3
- Reinforcement steel shall be 100 % recycled, or emissions for other products shall be correspondingly lower
- Leveling screed on top of wooden floors must be B10, low carbon class A
- Non load bearing internal walls avg. emissions: max 10 kg CO2e / m3

The data used to demonstrate compliance shall be EPDs in compliance with EN 15804, and EPDs must be demonstrated for at least 15 products used in the building. Product data must be delivered to project management.

Los Angeles Executive Directive "L.A.'s Green New Deal: Leading By Example" makes California's Buy Clean California Act mandatory for municipal projects. It requires carbon emissions reductions from construction materials, including steel, flat glass and insulation. This will be implemented at the beginning of 2021 for public buildings such as fire stations, civic centers and libraries.

The Norwegian government construction organisation Statsbygg applies a requirement for using only products with EPDs for concrete, steel, insulation materials, gypsum boards, natural stone, wood-based boards, floorings, ceilings and roofing membranes. Of these, concrete, steel, gypsum and insulation have maximum emission limits. For pilot projects, limits are set also for other material types. Concrete carbon limits have been set for different strength classes. For steel, requirement is expressed as recycled content. For insulation the requirements vary by type of insulation.

Furthermore, in France (and separately in Belgium) laws are in place for any construction product being marketed as a sustainable choice to have a published and third party verified EPD for the products. This law is called *Arrêté du 9 juillet 2014 modifiant l'arrêté du 23 décembre 2013 relatif à la déclaration environnementale des produits de construction et de décoration destinés à un usage dans les ouvrages de bâtiment.*

P1 - EXAMPLE LANGUAGE

For all public works funded or co-funded by the city, design, procurement and supply of following key construction materials and products either by or on behalf of the city shall be subject to the following requirements:

1. These requirements cover the supply of following product categories: Ready-mix concrete; precast concrete elements; cement; reinforcement steel; structural steel; bricks, glass; gypsum board; and insulation.
2. For all products in the above categories supplied for public works, the project shall implement the following embodied carbon transparency requirement: Projects shall require all suppliers to provide company-specific Environmental Product Declarations (EPD) in compliance with in EN 15804 / ISO 21930 and ISO 14025 with minimum scope A1-A3 manufacturing; and the EPD must be valid at point of specification and cover product(s) supplied.
3. Transport must be added using emission factor of [xxx] per ton-kilometer (meaning transport of one ton of mass over distance of one kilometer) if distance of transport exceeds [xxx]kilometers
4. Projects may apply for waiver for the embodied carbon transparency requirements until 31 December 2020 for up to three product categories. Thereafter, projects may apply for waiver for products that are used in small quantities only, defined as less than 5 % of applicable materials by mass for the project.
5. For each product type, the carbon performance requirement (max allowed embodied carbon emissions) for product type defined by A1-A3 in EPD are:

a. Ready-mix concrete up to C60 / 7000 psi compressive strength: maximum [xxx] CO2e/m3, when no strength class specific embodied carbon performance requirements are set
b. Precast concrete elements up to C60 / 7000 psi compressive strength: maximum [xxx] kg CO2e/m3, when no strength class specific embodied carbon performance requirements are set
c. Reinforcement steel: [xxx]
d. Structural steel: [xxx]
e. Bricks: [xxx]
f. Glass: [xxx]
g. Gypsum board: [xxx]
h. Insulation: [xxx]

6. Projects may apply for waiver for the carbon performance requirements until 31 December 2020 for all product categories. Thereafter, projects may apply for waiver for one product category. Any waiver for carbon transparency automatically also waives carbon performance requirement.
7. Product embodied carbon transparency and performance data, including EPDs, shall be recorded and submitted as part of the project documentation.

Projects achieving more than 25 % reduction from the defined maximum values that did not apply for any category waivers are eligible for further performance bonus.

P2 GREEN PUBLIC PROCUREMENT FOR PUBLIC BUILDINGS

REDEFINE THE SOLUTION

PROCUREMENT, MUNICIPAL BUILDINGS

CARBON IMPACT ●●○○○

IMPLEMENTABILITY ●●●○○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●●○

SUMMARY

Forcing all public buildings to follow green public procurement scheme that includes embodied carbon requirement may simplify municipal project requirement setting. When a city can use a national, federal or European Union set of requirements, or a suitable commercial green building certification system, those can be applied instead.

VARIANTS

The green public procurement policy can be connected to embodied carbon or life-cycle carbon performance targets and verification. In case of an existing set of requirements or a commercial certification, a specific requirement can be applied for fulfilling those requirements. This policy could also be connected to infrastructure works, with adaptations.

BENEFITS

Consolidating different building sustainability requirements to a comprehensive green public procurement policy simplifies management. Applying a broadly available public or commercial set of requirements allows a system that is being updated over time to reflect new approaches and also helps with availability of skills.

PRE-REQUISITES

A suitable green public procurement scheme that can be adopted in whole or in parts, or over time so when competence and funds to develop one for the city are available. City level green building policies have been developed for example for Hamburg HafenCity.

ENFORCEMENT

Enforcement bases on commercial contracts and is enforceable using similar mechanisms as any of the contract aspects.

P2 - SPOTLIGHT: Trondheim, Europe, US, UK and Finland

City of Trondheim, Norway, applies a template of environmental requirements for all their construction projects. The *Miljøkrav i byggeprosjekt* (June 2019) cover environmental management, health and environment, energy, material use, waste, area use and ecology and pollution. It covers also several carbon reducing topics including fossil free construction sites as well as project and product carbon requirements.

Green Public Procurement (GPP) for office buildings by European Commission. The GPP template is a flexible procurement scheme that incorporates different levels of technical ambition and complexity. For materials, it has different types of categories of demands, including use of recycled content in concrete and masonry (from 15 % to 30 % in main building elements) as well as carbon impacts of building materials with different options. It also includes reuse of demolition waste (from 55 % to 80 %) and limits to the amount of construction site waste generated (from 110 to 70 kg per square meter GIFA). The criteria for materials emissions are in decreasing order of ambition and complexity: 1) LCA for main building elements; 2) collect EPDs for main building elements; 3) require recycled and re-used content; and 4) require reducing transportation impacts of heavy materials.

The US Green Procurement Compilation lists General Service Administration's contracts and it includes several green construction materials and roadway constructions.

The Official Government Buying Standards (UK) for construction/refurbishment projects and products. For projects, it essentially requires use of a BREEAM certification system, but does not require using LCA part of BREEAM certification.

A national Green public building - Procurement guide is also available for Finland. It incorporates life-cycle carbon emissions reduction.

P2 - EXAMPLE LANGUAGE

All public buildings constructed for the city shall comply with one of the following:

a) Green Public Procurement Criteria. Project shall comply with all Core level criteria defined in European Commission's Green Public Procurement Criteria for Office Building Design, Construction and Management, and in addition with the Comprehensive criteria B10.1 Performance of the main building elements, B10.3 Performance requirements for CO2e emissions from the transportation of aggregates and C1. Demolition waste audit and management plan.
b) LEED v4.1 with at least Gold rating level, including achieving the following credits: Building Life-Cycle Impact Reduction (minimum 4 points), Building Product Disclosure and Optimization - Environmental Product Declarations (minimum 1 point) and the pilot credit Procurement of Low Carbon Construction Materials (minimum 2 points).
c) BREEAM UK NC 2018 with at least Excellent rating level, including achieving the following credits: Mat 01 Environmental impacts from construction products (minimum 7 points), Mat 02 Environmental impacts from construction products - Environmental Product Declarations (EPD) (1 point) and Mat 06 Material efficiency (1 point).

BREEAM International 2016 with at least Excellent rating level, including achieving the following credits: Mat 01 Life cycle impacts (minimum 6 points + exemplary point) and Mat 06 Material efficiency (1 point).

P3 REQUIREMENT OF RECYCLED AGGREGATES

REUSE

PROCUREMENT, INFRASTRUCTURE, WASTE & CIRCULARITY

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●●○	**ENFORCEABILITY**	●●●●○

SUMMARY

Develop a procurement policy that sets a minimum level of recycled or reused aggregates and soils in municipal projects, if available within a predefined sourcing radius. The designers can choose the optimal uses for those masses based on the project. This type of policy would have most impact on infrastructure works.

VARIANTS

If recycled or reused masses are subject to permitting outside control of the city, the policy can be written to allow for being approved the use of such materials.

BENEFITS

Recycled aggregates and soils end up on landfills and permanently out of circulation. This will lead to further disturbance of virgin land and extraction of virgin rock. This will protect local natural areas.

PRE-REQUISITES

Using recycled aggregates must be legally possible (even if permitting needed).

ENFORCEMENT

Enforcement can be part of general contract enforcement.

P3 - SPOTLIGHT: Copenhagen and France

Copenhagen, Denmark requires in their Sustainability in Construction and Civil Works that "Road-building works must use crushed builders' rubble as a substitute for base gravel, provided that this is technically or economically sustainable. Requirements for environmental quality have to be met. The crushed rubble must not contain any bricks, tiles or concrete that could be reused instead". These requirements apply both to projects the City commissions, as well as the projects the City supports.

France has a current goal to achieve a 50 % share of reused or recycled building waste materials in road construction for materials bought by national and local authorities in 2017, rising to 60 % by 2020. This can help ensure having a market for most of the recycled aggregates processed from construction and demolition waste.

P3 - EXAMPLE LANGUAGE

For all public works funded or co-funded by the city, design, procurement and supply of earth masses and aggregates either by or on behalf of the city for city projects shall be subject to the following requirements:

All [or at least 80 % by volume of] earth masses used for municipal works shall be from non- virgin soil, if such is available within a 30 km [20 miles] radius from the project location. Exception to this may only be granted if a permit application for use of these materials is returned in the final verdict as rejected.

All [or at least 80 % by volume of] aggregates used for municipal works shall be from non- virgin rock, if such is available within a 30 km [20 miles] radius from the project location. Exception to this may only be granted if a permit application for use of these materials is returned in the final verdict as rejected.

P4 LOW-CARBON ASPHALT PROCUREMENT

REQUIRE LOW CARBON PRODUCTS

PROCUREMENT, INFRASTRUCTURE

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●○○

SUMMARY

Require that all asphalt suppliers document and report their asphalt carbon intensity by using EPDs. Extend the transparency requirement to carbon performance or a bonus.

VARIANTS

An alternative method would be to provide a fixed green asphalt bonus for suppliers delivering asphalt meeting the criteria for each ton purchased. This could be offered for a few years as a fixed-term market transformation program during which the local asphalt plants are able to upgrade their energy supplies to low carbon ones.

BENEFITS

The public sector is the main purchaser of asphalt and has significant impact on the industry. Low-temperature asphalt saves manufacturers energy costs, which can help fund investments into plant and machinery upgrades.

PRE-REQUISITES

This policy normally requires no rights or powers. However, the implementation must be done in a manner that does not infringe state aid rules, especially in EU.

ENFORCEMENT

Enforcement may be required to verify results of calculations and to award bids.

P4 - SPOTLIGHT: Norway and Netherlands

Norwegian government roads authority, Statens Vegvesen has a requirement for all suppliers for asphalt and few other key product categories to provide an EPD when bidding for work. The comparison carbon intensity for the asphalt (delivered to site, so scope A1-A4 as per EN15804) is 60 kg CO2e per ton. All bidders shall get either a penalty or bonus on their comparison price based on the carbon intensity of the asphalts offered. Before this a simpler fixed bonus for low temperature asphalt was offered.

Furthermore, Dutch Rijkswaterstaat has operated life-cycle assessment based awards scheme for several years, which also includes asphalt but is not specific to it.

P4 - EXAMPLE LANGUAGE

For all public works funded or co-funded by the city, design, procurement and supply of asphalt either by or on behalf of the city shall be subject to the following requirements

Performance-based example:

1. For asphalt, the highest allowed embodied carbon emissions from the raw materials and supply of the asphalt for scope A1-A4 as defined in EN 15804 / ISO 21930 is not higher than 60 kg CO2e per ton.
2. When asphalt would be transported to multiple sites in different locations over the contract, the city hall address shall be used for evaluating the transport distance from the asphalt plant to the construction site. The return trip of the asphalt trucks will also be included in calculations.
3. Acceptable method to demonstrate compliance with these requirements is a company and product specific EPD prepared in compliance with ISO 14025 and EN 15804/ISO 21930 which must not be expired at point of specification. The EPD shall either be able to demonstrate a variability no higher than 10 % or be plant-specific to the plant supplying the asphalt.

Prescriptive example:

- As of 2021, all asphalt purchased for municipal works shall be either made with low-temperature manufacturing or with non-fossil fuels.
- As of 2023, all asphalt purchased for municipal works shall be made with both low-temperature manufacturing and with non-fossil fuels.

P5 REQUIRE USE OF CERTIFIED WOOD PRODUCTS

REQUIRE LOW CARBON PRODUCTS

PROCUREMENT

CARBON IMPACT	●○○○○	IMPLEMENTABILITY	●●●○○
COST-EFFICIENCY	●●●○○	ENFORCEABILITY	●●●○○

SUMMARY

This policy requires the use of certified wood products when appropriate in all projects for which municipal procurement guidelines apply. The required certification system should be determined by the jurisdiction and should have standards that have been demonstrated to produce wood with a lower embodied carbon footprint.

VARIANTS

This policy could be expanded to apply to non-municipal projects as well through building code.

BENEFITS

Some certified sustainably forested wood products have been shown to have lower embodied carbon and reduced negative ecological impacts. Supporting sustainable forestry has the potential to increase soil carbon sequestration and mitigate human rights concerns, biodiversity loss as well as environmental degradation that can result from unregulated forestry.

PRE-REQUISITES

No prerequisites have been identified for this policy.

ENFORCEMENT

This policy can be enforced by the authorities that oversee and enforce existing procurement.

P5 - SPOTLIGHT

Many cities across the world implement this type of policies already.

P5 - EXAMPLE LANGUAGE

Intent: The intent of this policy is to ensure that certified sustainably forested wood products, and no uncertified wood products, are used in municipal construction projects of all kinds, thereby reducing the embodied carbon of municipal construction projects.

Requirements: The jurisdictional procurement authority must only use wood products certified by [insert chosen certification shown to have lower embodied carbon – including FSC and PEFC]. No uncertified wood products may be used.

P6 CIRCULAR MATERIALS PURCHASING STRATEGY

REDEFINE THE SOLUTION

PROCUREMENT, WASTE & CIRCULARITY

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●○○○	**ENFORCEABILITY**	●●●○○

SUMMARY

Implement a strategy to define procurement in a manner which ensures that the market will either certainly or very likely deliver a circular solution in response. Procurement can be designed to focus on materials efficiency, circularity, maintainability, repairability and end of life opportunities.

VARIANTS

Solutions can even be redefined to a service, such as leasing some of the elements.

BENEFITS

Circular procurement demonstrates the market for direct cash value circular products.

PRE-REQUISITES

No prerequisites have been identified for this policy.

ENFORCEMENT

This policy can be enforced by the authorities that oversee and enforce existing procurement.

P6 - SPOTLIGHT: Rotterdam

The City of Rotterdam, Netherlands, signed in 2019 with other municipalities and construction sector partners a circular concrete covenant. It contains agreements on the efforts that all the entities will make to recycle building and demolition waste as well as how this will be accomplished.

Netherlands in general has long been a leader in green public procurement. This is discussed for example in report 100%? Six years of sustainable procurement in the Netherlands. Also in Norway, national best practises have been published.

P6 - EXAMPLE LANGUAGE

All products and materials ordered and used in public works funded or co-funded by the city, that have an estimated service life of no more than [x] years, which can be subject to repair and maintenance as well as those with project value is at least [x] EUR or [x] USD are subject to the following requirements:

- Products and materials have demonstrated maintainability strategy, including access to replaceable parts and availability of standard parts.
- Products and materials have a demonstrated repair strategy, including that uninstalling the product and material in part for repair is possible.
- Products and materials have a demonstrated disassembly and reuse or recycling strategy, including that parts have material labels and the parts can be separated from each other.

Exceptions to maintainability and repair strategies may be granted where neither maintenance or repair are needed, or where market cannot offer such products.

11. INFRASTRUCTURE

I1 EARLY DESIGN CARBON TARGETS FOR INFRASTRUCTURE

REDEFINE THE SOLUTION

INFRASTRUCTURE, PROCUREMENT

CARBON IMPACT	●●●○○	IMPLEMENTABILITY	●●●○○
COST-EFFICIENCY	●●●●○	ENFORCEABILITY	●●●●○

SUMMARY

Infrastructure projects can reduce both materials use and carbon significantly. As projects vary, targets must be set on project by project basis. They can be set as part of early design. The later design and construction must then meet these auditable targets. This can be started with accounting requirement if needed. This requirement can also apply to municipal funding requests.

VARIANTS

Carbon accounting for the infrastructure project itself at lowest level covers only the project itself (as project materials and energy over its lifetime). At a higher level, before the project decision is made, the project's impact on carbon of the transport system (if transport project) may be analyzed, for example, along with other impact assessments. Typically, the system level impacts dominate the total impacts of infrastructure projects. Sometimes, project variants considered at a later point may still have differences in transport system carbon impacts. In this case, the policy could and should be extended to cover those.

BENEFITS

If carbon is set as design requirement early on in a project, the project starts to focus on energy and materials efficiency opportunities sooner. This will also help rule out some of the most material inefficient solutions.

PRE-REQUISITES

City must be one of the major investors in infrastructure projects to influence them.

ENFORCEMENT

The enforcement should be tied into the investment decision and contracts process.

I1 - SPOTLIGHT: Stockholm

City of Stockholm has since 2018 required carbon footprint declaration for all municipal infrastructure projects costing at least 50 MSEK (4,7 M€ or $5.3M).

This policy is now proposed to be extended and a draft is out for consultation: Plan för begränsad klimatpåverkan i bygg- och anläggningsprojekt.

The proposal could extend the usage of the accounting in larger projects and could also aim to cover the smaller projects in their entirety by 2021. The proposal recommends that projects looks at the whole life-cycle, including use phase climate impacts (B1-B7) for choosing implementation method, and that the end of life impacts and options (C1-C4) be studied ar the early project, but ultimately requires that only the material (A1-A3) or upfront (A1-A5) emissions be calculated according wiht the references in the European Standard EN 15978. Stockholm approach draws on some synergies with the national infrastructure body Trafikverket's requirements.

I1 - EXAMPLE LANGUAGE

All infrastructure projects to be constructed with municipal funds whose cost estimate is at least 10 MEUR ($11.4M) shall implement the following requirements.

In general planning phase, projects shall estimate the project life-cycle carbon impacts for the project when built on a business as usual basis for the foreseen plan, using typical construction quantities and materials, including following life-cycle modules at the minimum: A1-A3 Construction materials, B4-B5 Replacement of materials in use, B6 Operational Energy, and C1-C4 End of life. The calculation shall not deduce the end of life benefits (D). The assessment period shall be set to 100 years. The calculation shall follow European Standard EN 15978, PAS 2080 or a national standard when one is available.

Projects shall be required to reduce the life-cycle carbon impacts by at least 30 % from the business as usual carbon impacts using any means necessary but excluding purchasing of offsets. Projects may for example change routing or design, improve materials efficiency or lifespans, use lower carbon materials or use less energy. The achievement must be demonstrated at the end of the technical design phase.

The requirement target must be set as a contractual requirement for the procurement, to which the successful tendered must commit to, and which the successful tenderer shall be required to deliver. If the contractor either fails to disclose the results or discloses results that fail to meet the target, a contractual penalty worth 5 % of the value of the contract shall be levied.

Projects can use any tools of their choice that are shown by compliance certification, or other reliable means to follow the methodology.

To demonstrate compliance, projects shall submit a carbon calculation report in line with the required methodology as well as the bill of materials and energy used for the calculation, to allow a verification of the calculation plausibility.

City reserves the right to audit submitted data for plausibility both at the time of application and at time of completion. City may request for updated calculations at the completion time, as well as clarifications at any time. Omitting to answer to such requests in timely or complete manner may lead to application being rejected.

I2 WOOD FOR LIGHT BRIDGES AND SMALLER STRUCTURES

REDUCE & REPLACE MATERIALS AND STRUCTURES

INFRASTRUCTURE

CARBON IMPACT ●●○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●●●

SUMMARY

The municipal authority can prioritize or require the use of sustainable sourced wood as an alternative to other materials for light bridges, noise and traffic barriers as well as all other municipally constructed or funded infrastructure for which wood is an appropriate material..

VARIANTS

Existing municipal procurement rules or guidelines can be adapted to include a preference or requirement for wood when appropriate. Prior deciding the material for infrastructure project, city can confirm the best adapted material using an LCA methodology.

BENEFITS

Smaller infrastructure in cities, such as pedestrian bridges and noise barriers, can be served cost-efficiently by wood structures. The use of sustainably forested wood as an alternative to materials for higher embodied carbon reduces the overall embodied carbon of projects, and in some cases results in net carbon sequestration.

PRE-REQUISITES

The jurisdiction must have reasonable access to sustainably forested wood.

ENFORCEMENT

This policy can be enforced by the authorities that oversee and enforce existing procurement rules. Wood may be given a preferential position in such process.

I2 - SPOTLIGHT

Many examples of effective use of wood for small scale structures exist, but no examples of policies targeted to increase or incentivize the use of wood in municipal infrastructure projects have been identified.

I2 - EXAMPLE LANGUAGE

Procurement rules or guidelines establishing a preference or requirement for the use of wood for all appropriate light structures can be adapted from existing municipal or governmental procurement guidelines. Or they could follow the template below:

Intent: The intent of this policy is to maximize the use of sustainably forested wood as an alternative to other materials in municipal construction projects, thereby reducing the embodied carbon of municipal construction projects.

Requirements: The jurisdictional procurement authority must give preference to sustainably forested wood to the maximum extent feasible throughout design and construction of all projects. Criteria for determining what wood qualifies as sustainably forested will be defined by a working group of experts in collaboration with the jurisdiction. The use of wood in the construction of all eligible structures should not adversely affect the performance or safety of the system or structure for which the material is used.

Eligible structures: Light bridges, noise and traffic barriers as well all other municipally constructed or funded infrastructure for which wood is an appropriate material.

Exemptions: Projects that demonstrate one of the following may be exempt from this policy:

- Embodied carbon reduction of [xx%] or more against an established baseline for comparable projects
- A clear project specific need for project wide use of materials other than wood

I3 USE VEGETATION FOR WATER MANAGEMENT

REDEFINE THE SOLUTION

INFRASTRUCTURE

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●●○

ENFORCEABILITY ●●●●○

SUMMARY

Cities can generally determine which spaces remain green and which can be or must be paved over. Even at a plot level, a 'green space factor' can be implemented to require that certain portion of the area must be green. Furthermore, for carbon sink purposes, types of green spaces could be graded to substitute for very heavy investments in drains, water channels and other concrete infrastructure.

VARIANTS

Some cities provide stormwater compliance incentives. Trees with long roots (over 3 meters) can also help rainwater penetrate to the lower levels of soil and to go through the compact topsoil layer.

BENEFITS

Green spaces can also increase enjoyability of the external areas.

PRE-REQUISITES

The city must be able to set requirements for zoning in regards stormwater management.

ENFORCEMENT

If the Green Spaces are set as a requirement and these are enforced via the zoning process so that the city monitors its own staff drafting the zoning plans.

I3 - SPOTLIGHT: Helsinki and Seattle

City of Helsinki, Finland, uses a "green co-efficient" to determine how large area of the plot must be reserved for vegetation and water slowing solutions. City of Seattle, United States, uses also a Seattle Green Factor to similar ends.

I3 - EXAMPLE LANGUAGE

Each new district level zoning project shall evaluate green factor for the area. The green factor shall comprise the part of the plot set aside for trees or shrubs, as well as areas left uncovered by concrete or asphalt. Such calculation may use an appropriate software tool.

I4 PARK MANAGEMENT FOR CARBON SEQUESTRATION

REDEFINE THE SOLUTION

INFRASTRUCTURE

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●●●

SUMMARY

Implement carbon-sequestering land management practices for appropriate city-owned open space and park land, including:
- Preservation of forested areas
- Preference for climate-appropriate trees, shrubs and grass over paved area
- Strategic application of compost
- Other scientifically supported strategies for increasing ecosystem carbon sequestration

Properties to which the policy applies should complete and submit carbon sequestration plans outlining the practices they will adopt to increase landscape carbon sequestration.

VARIANTS

Incentives could be developed for owners of private land who designate a significant portion of the area of their properties as carbon sinks, adopt carbon-sequestering land management practices for that area and/or measure and report annual increases in soil carbon.

BENEFITS

Prioritizing ecosystem carbon sequestration in the management of parks and open spaces enables cities to design and preserve places that can act as long-term carbon sinks, while also resulting in significant co-benefits, including improved soil health, improved water management and flood mitigation, increase in biodiversity, mitigation of urban heat island effects, improved air quality and increased access to green space.

PRE-REQUISITES

City ownership of appropriate open space and park land is a prerequisite, as is public acceptability of visual changes in parkland.

ENFORCEMENT

Carbon sequestration plans should be approved by a committee with scientific expertise in landscape carbon sequestration. Sites should be evaluated on a regular basis to confirm that practices outlined in the carbon sequestration plan are being maintained or improved upon. These regular reports should include quantitative data on indicators of landscape carbon sequestration, such as the number and age of trees, the area of preserved forest or shrubland, and soil carbon measurements.

I4 - SPOTLIGHT: Marin County

The Marin Carbon Project demonstrated techniques for carbon sequestration in rangeland, agricultural and forest soils through applied research, demonstration, and implementation.

I4 - EXAMPLE LANGUAGE

Intent: It is the intent of this policy to increase landscape carbon sequestration in publicly owned and managed land, including parkland and open space.

Eligible spaces: Eligible land includes parkland, open space, forested areas, and other spaces identified by the Department of [insert appropriate department or office].

Requirement: Managers of all eligible lands must complete and submit carbon sequestration plans outlining the practices they will adopt to increase landscape carbon sequestration. On an ongoing basis, they must comply with review and submit reports on a biennial basis providing evidence that practices outlined in the carbon sequestration plan are being maintained or improved upon. Biennial reports should include quantitative data on indicators of landscape carbon sequestration, such as the number and age of trees, the area of preserved forest or shrubland, and soil carbon measurements.

I5 PLANT TREES IN CITY SPACES AND UNBUILDABLE AREAS

REDEFINE THE SOLUTION

INFRASTRUCTURE

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●○○○

ENFORCEABILITY ●●●●●

SUMMARY

When city areas have been found to have no potential for low carbon construction, implement a reforestation program to increase carbon sinks and possibly creating recreational spaces at the same time. In addition, plant additional trees in city spaces where feasible, from creating boulevards to adding trees on plazas.

VARIANTS

Choosing tree species that increase soil carbon sinks increases effectiveness.

BENEFITS

Besides improving the soil, trees also reduce impact of urban heat islands.

PRE-REQUISITES

No pre-requisites were identified for this policy.

ENFORCEMENT

As this type of program would be executed on municipal chain of command internally or with external contracts, normal enforcement would generally be enough.

I5 - SPOTLIGHT: Budapest

Budapest planted about 10 000 trees between 2016 and 2019 in urban areas as part of program to create shades and increased flood and stormwater management.

I5 - EXAMPLE LANGUAGE

Parks and recreation department shall be responsible for achieving each year an increase of soil and biomass carbon sinks by [x] tons. The tons are calculated as result of the vegetation planted annually over the normal growth cycle of the trees planted, set at 60 years if not defined. This shall be achieved by planting trees and other types of vegetation on the city land, including both urban land and vacant land.

12. WASTE AND CIRCULARITY

W1 DESIGN FOR DISASSEMBLY AND ADAPTABILITY CRITERIA

REUSE PRODUCTS AND MATERIALS

WASTE/CIRCULARITY, BUILDING REGULATION

CARBON IMPACT	●●●○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●●●	**ENFORCEABILITY**	●●●○○

SUMMARY

Most materials are installed in a manner to make only destructive demolition possible, which prevents material reuse as product. Specific set of prescriptive policies could target the highest value disassembly targets, those which are likely to have shorter lifetime or high reuse potential. The design for disassembly method for the key elements and systems would be submitted as part of planning and occupancy permit applications.

VARIANTS

Design for disassembly relates also to design for adaptability. Adaptability may be more subjective to evaluate, unless specific adaptations can be identified for projects for example, due to demographic change.

BENEFITS

Structural building elements (natural disasters excepted) often stay intact for the whole lifetime of a building. Reusing columns, beams, walls and floors would be possible, if the connections used to join them together are possible to undo. Furthermore, several non-structural materials, for example gypsum boards, windows and doors can be reused as a material within the building when renovating and if the method of installation considers disassembly costs savings can be made.

PRE-REQUISITES

That city can impose requirements on construction methods.

ENFORCEMENT

Enforcement would be based on city's general authority to review plans. Considering connections design is done only at later stages of a project, reviewing connections design could be required for occupancy permit phase, with planning permit only requiring that intended methods be defined. It is worth noting that ready-mix concrete buildings may very well require completely new technical solutions to be possible to build in line with this type of requirements.

W1 - SPOTLIGHT: Venlo

No city level policy implementations were identified. However, as an individual building, Venlo city hall in the Netherlands has been designed and built using design for disassembly practices. Netherlands is currently developing a design for disassembly standard.

Technical solutions to facilitate the disassembly of building elements exist. These include for example all steel structure connections, most of the wood structure connections and those precast concrete connections that have been designed for disassembly. The main construction method that cannot be disassembled is ready-mix concrete.

For precast concrete, uncoupled connections are available on the market (some examples). Connections can be protected by using cover caps or lime mortar for protective casting around the connections. Lime mortar can be removed by hydroblasting, which allows opening connections and moving elements for reuse.

W1 - EXAMPLE LANGUAGE

All projects submitting a construction permit application must provide their intended design for disassembly strategy for the project, including how physical access to connections is enabled, and what is the mechanism for undoing the connections for the required elements. The required elements include:

- Beams and columns
- Floor slabs and external walls
- Internal walls and partition walls

Further, all projects larger than 10000 m^2 (110,000 square feet) shall be required to deliver a connections review of the implemented connections design to ensure that connections for the required elements are both physically accessible and can be uncoupled. The connections review shall demonstrate types of connections used in the project and include photographs demonstrating the connections as implemented.

W2 MANDATORY PRE-DEMOLITION AUDITS & DATA SHARING

REUSE PRODUCTS AND MATERIALS

REGULATIONS, WASTE/CIRCULARITY, MUNICIPAL BUILDINGS

CARBON IMPACT	●●○○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●●●	**ENFORCEABILITY**	●●●●○

SUMMARY

Establish a requirement for all demolition and larger renovation permit applications to include a detailed pre-demolition audit. Make those pre-demolition audits public and allow a waiting time during which materials salvaging operators can recover what materials they commercially agree to recover from the building owner as opposed to instant demolition.

VARIANTS

Allow expediting process over this cooling off period only if significant salvage is otherwise assured, for example by showing already made salvaging arrangements. Making the policy stronger, either a minimum salvage rate could be required, or higher salvage rate could be provided a bonus.

BENEFITS

Demolitions happen too fast to allow commercial salvaging to take place. Requiring preliminary salvageable materials audits and publishing them for allowing commercial salvaging to take place, can reduce demolition cost and will reduce the amount of materials ending in landfills. This will allow salvaging operators to pick from materials available the ones they can commercialize at a profit. Typically, operators charge a fee from the owners, as they will reduce landfilling fees.

PRE-REQUISITES

Authority to require pre-demolition audit, publishing it and enabling a marketplace creation. Process or requirement for pre-demolition audits. In the European Union / European Economic Area, the salvaged materials may require new CE-marking.

ENFORCEMENT

The publishing of the pre-demolition audits for salvaging operators allows those projects to be quickly screened for available potentially commercialize materials. If salvaging itself is not required, no further enforcement is required.

W2 - SPOTLIGHT: Luxembourg, Europe, Finland, Stockholm, Denmark

However, the Grand Duchy of Luxembourg requires in the law of 21 March 2012 on waste management (article 26) that all prior any demolition, materials in the object of demolition must be identified, and when identification is not possible, this must be justified, and collected in an inventory in line with national guidance. However, the law is weakly enforced.

Guidelines for the waste audits before demolition and renovation works of buildings (Waste Audit Guidelines) is a voluntary European protocol for pre-demolition audits of buildings that intend to help ensure recovery of recyclable material streams. It supports achieving high quality separated waste fractions. EU Construction and Demolition Waste Management Protocol is a supplementary waste logistic guidance.

A national Finnish Pre-demolition Audit – A Guide for Authors does same nationally. It is a mandatory requirement for being eligible for deconstruction funding from ARA, which funds construction and renovation of social housing in Finland.

Improving quality of construction & demolition waste – Requirements for pre-demolition audit is a Nordic level attempt to define the same.

Number of City of Stockholm property companies have adopted a resource and waste policy for construction and demolition (Resurs- och avfallsriktlinjer vid byggande och rivning, May 2019).

Danish Ressourcekortlægning af bygninger defines material mapping in Denmark.

W2 - EXAMPLE LANGUAGE

All applications for a demolition permit or renovation permit for a surface higher than 100 m2 (1080 square feet) shall supply a pre-demolition audit prepared according to the Guidelines for the waste audits before demolition and renovation works of buildings (European Commission, 2018).

The provided pre-demolition audit shall be published with contact details to the applicant by the city for a period of six weeks, during which time the applicant is encouraged to agree with material salvaging companies on stripping of reusable products from the building to reduce demolition and waste handling costs.

If the applicant can demonstrate an existing arrangement to strip at least 50 kg of reusable products per square meter, the period can be shortened to four weeks. Reusable products only include products and materials which are recovered as entire products, not as raw materials for recycling.

W3 MANDATORY MATERIAL TAKEBACK PROGRAM

REUSE PRODUCTS AND MATERIALS

REGULATIONS, WASTE/CIRCULARITY, MUNICIPAL BUILDINGS, INFRASTRUCTURE, PROCUREMENT

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●●●	**ENFORCEABILITY**	●●●●○

SUMMARY

As a condition of the construction permit, require commercializing unused (surplus) construction materials and products. Require that applicant has an appointed construction materials takeback operator for unused products. The takeback program operator shall commercialize useable construction materials, thus avoiding them being landfilled, incinerated or recycled. Takeback program operator is required to commercialize, for example, min. 97 % of received materials by weight. Takeback operator can be a specialized operator, a wholesaler or a waste management firm.

VARIANTS

The same policy could also be applied in connection with a waste container placement permit, which is often required for renovations (for placing one on city property), or otherwise via the solid waste division of the city.

BENEFITS

Currently, significant portion of unused construction materials end at landfill. Landfilling or recycling unused construction materials is costly compared to using them. Commercialization business typically operates at collecting the goods at a low fee or no fee and resells the products at a discounted cost compared to new products. This creates a product value preservation opportunity instead downcycling. Unused materials can be several percentages of total site materials, excluding concrete. They are hard to commercialize directly from the site via quantities and specifications mismatch.

Program can work practically for all construction materials, including finishing materials and building services components.

PRE-REQUISITES

Regulatory authority to require this for construction sites, e.g. based on waste policy. Having enough lead time from policy announcement for takeback operator activities be initiated is also necessary.

ENFORCEMENT

Enforcement can be simplified by requiring operator(s) to be named on the permit application, which provides the operator(s) an incentive to monitor actual outcomes. Enforcement can be strengthened by requiring operators to be approved.

W3 - SPOTLIGHT

Commercial takeback agreements are commonly used for large commercial construction projects that enjoy strong purchasing power for high value categories. Takeback agreements are also provided by some wholesaler companies.

W3 - EXAMPLE LANGUAGE

As part of construction / waste container permit application, the applicant shall:

Submit the appointed takeback operator or operators for unused construction goods, including documenting their compliance with the city requirements. No further documentation is required for any takeback operator listed on the city's website.

Appointed takeback operators must be operating a commercial scale unused goods commercialization solution within the city. Takeback operators must be registered business or charity and have not been subject to environmental degradation fines or sanctions in the past three years. The operators must not have tax debts. The operators must commercialize minimum of 97 % of the received material by weight. The takeback operator site of processing be selling the materials to users directly.
All unused and unspoiled as well as all fully usable construction materials and goods are required to be provided to the takeback operator. These materials are considered to include all materials which are no longer needed at the site but are still usable for their original purpose. Such materials may not be sent for waste disposal. The requirement does not apply to demolished materials, earth masses or individual pieces of products weighing below 30 kilograms.

The project must provide a record of surplus goods received by the takeback operator on completion. The record must be issued by the takeback operator.

W4 SOIL COORDINATION FOR MASS STORAGE AND REUSE

REUSE PRODUCTS AND MATERIALS

WASTE/CIRCULARITY, BUILDING REGULATION

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●●●

ENFORCEABILITY ●●●●○

SUMMARY

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.

VARIANTS

Working via soil coordination can be a requirement for getting a permit for example. In jurisdictions where city's permit is de facto required (e.g. if city is so large that transporting soil outside of the city is not feasible) to dispose of soils or use them for backfills, can be also used as a mechanism for enforcement. Lastly, soil coordination is possible also via zoning for larger areas, where areas for temporary soil storage for the construction phase of a district may be defined for a 10-year period. The policy can also be extended to masses from demolition projects.

BENEFITS

Soil coordination can significantly decrease soil transport distances and thus reduce carbon emissions from their transport and achieve a high degree of reuse of soils. It also allows extraction of virgin soil for fills and avoids creating soil disposal sites.

PRE-REQUISITES

City needs a planning and coordination system for managing soil transports and storage, designated storage areas and connection to planning and/or regulation.

ENFORCEMENT

Enforcement can happen through construction permits, zoning or disposal permits. It can be also voluntary, as it can save in cost. However, this may not achieve big scale.

W4 - SPOTLIGHT: Helsinki

City of Helsinki started land mass coordination in 2011, and the practice was extended with a land mass coordinator in 2014. The program selected eight temporary land mass storage areas for managing and processing land masses. These are also considered in master planning. The land mass coordination has been estimated to have created savings of 37 million euros (M4.1$) and 13400 tons of CO_2 to date. The program has resulted in nearly tripling the reuse of land masses in construction projects in Helsinki between 2014 and 2017. One large beneficiary project was Myllypuro disposal site refurbishment to a recreation park. This project was estimated to have saved 3,8 M€ (M4.2$) and 1000 tons of CO_2. The practice has been now decided to be rolled out also in the neighboring City of Espoo.

W4 - EXAMPLE LANGUAGE

This policy requires a soil coordinator role to be established within the municipality. The soil coordinator oversees collecting the information and plans from different city departments to ensure that future construction plans, their timing and estimated mass supply as well as demand can be forecasted and planned for. Soil coordinator may help establish mass balances for newly zoned districts, for example. The policy also requires setting out areas for temporary soil storage.

Implementation of the mass coordination can be supported by zoning decisions requiring that any fills needed use only non-virgin soil, by requirements set in municipal and state/province/federal infrastructure projects and in all municipal construction.

W5 INFORMATION ON ADAPTABILITY AND WASTE REDUCTION

REUSE PRODUCTS AND MATERIALS

WASTE/CIRCULARITY, BUILDING REGULATION

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●●

COST-EFFICIENCY ●●●●○

ENFORCEABILITY ●●●●●

SUMMARY

This program model provides designers, builders and developers with information on cost savings/financial benefits to be gained from reducing waste and information on converting existing buildings for adaptive reuse projects by selecting, procuring, and building with low-embodied carbon materials, and designing with later adaptation and reuse of buildings and materials in mind. This can be accomplished through technical assistance, including educational workshops and trainings (which may also be required or incentivized for large-scale developers operating in the city), through dissemination of financial analyses for low-embodied carbon project precedents, cost charts, as well as information on available tax incentives for donations of salvaged material and/or through the establishment of an office, internal resource center, or coordinator position to connect builders with information and expertise.

VARIANTS

This program could be implemented as an extension to existing educational or informational programs targeted to designers, builders, developers and property owners, if such programs exist.

BENEFITS

Access to educational materials lowers the informational barriers for designers, builders and developers to design and build for embodied carbon reductions. Additionally, increasing awareness of the potential cost helps conserve materials, recycle, and limit waste. Also, awareness of the lifetime cost savings and benefits of designing for adaptability creates an incentive for adaptive reuse and adaptable design.

PRE-REQUISITES

No prerequisites have been identified for this program.

ENFORCEMENT

No enforcement is necessary unless the educational programming is made mandatory, in which case enforcement can be managed at the point of approval of contracts when developers seeking contracts with the city, or at the point of certification if there are existing certification requirements for large-scale developers.

W5 - EXAMPLE LANGUAGE

The process for creating an information or education program with a focus on embodied carbon could follow the template below:

Intent: It is the intent of the City to provide information on converting existing buildings for adaptive reuse projects by selecting, procuring, and building with low-embodied carbon materials and designing with later adaptation and reuse of buildings and materials in mind. With the ultimate goal of enabling and supporting low-embodied carbon construction and development.

Program: To accomplish this goal, the City will design a program to create and host regular educational workshops and trainings, disseminate online informational materials, and provide other informational resources as well as support to builders and developers.

Allotment of resources: The City will allot funds to this program in the amount of [$X] per year for the hiring of consultants and educators to create and distribute educational materials and payment of expenses associated with educational workshops and events.

Appointment of personnel: The City will appoint an office, internal resource center, or coordinator position to connect designers, builders and developers with information and expertise.

Timeline: The City shall establish a timeline for informational and educational programming a year in advance to ensure that informational and educational events are widely publicized and well attended.

W6 MATERIALS LONGEVITY POLICY

REQUIRE LOW CARBON PRODUCTS

WASTE/CIRCULARITY

CARBON IMPACT	●○○○○	IMPLEMENTABILITY	●●●○○
COST-EFFICIENCY	●●●●○	ENFORCEABILITY	●●●●○

SUMMARY

This policy sets prescriptive requirements for the long-lasting design and use of long-lasting building materials. Further research must be conducted by the enforcing jurisdiction to determine the exact requirements, balancing the expected life span of a given material with its initial embodied carbon footprint, its potential for later reuse or recycling, and also the cost, availability, and local needs. For example, PVC windows have a significantly shorter lifetime than wood-aluminum windows. This policy shall not apply to any buildings with planned short life-time.

VARIANTS

A more comprehensive version of this policy could require protection of materials that are easily damaged in buildings in the region due to floods, moisture, or other statistically frequently recurring accidents. Such requirements would have to be set locally based on recurrence risk and type of risk exposure.

BENEFITS

Materials with longer lifespans need to be replaced less frequently, which reduces embodied carbon over the lifetime of the building. Durable materials that retain value and functionality over the course of their lifetimes are also more suited to reuse at the end of a building's lifespan.

PRE-REQUISITES

No prerequisites have been identified for this policy.

ENFORCEMENT

Building inspections after new construction or renovation projects must confirm that the most suitable materials have been used before a building is permitted for occupancy.

W6 - SPOTLIGHT: North Bend and Tuttle

No examples of prescriptive requirements for general material longevity have been identified. However, North Bend, Washington and Tuttle, Oklahoma's bans on vinyl siding were based on that material's short lifespan.

W6 - EXAMPLE LANGUAGE

Procurement rules or guidelines establishing prescriptive requirements for the use of long-lasting building materials can be adapted from existing material standards or procurement guidelines, or could follow the template below:

Intent: The intent of this policy is to maximize the of durable, long-lasting, and reusable materials in construction projects of all kinds, thereby reducing the embodied carbon associated with maintenance and replacement.

Requirements: The jurisdiction will conduct research to determine a set of prescriptive requirements for building materials, requiring that materials used in new construction and renovation meet standards for durability, longevity, and reuse potential. In determining the standards, the jurisdiction will balance the expected life span of a given material with its initial embodied carbon footprint, its potential for later reuse or recycling, and also with cost, availability as well as local needs.

Exemptions: Projects that demonstrate one of the following may be exempt from this policy:

- Embodied carbon reduction of [xx%] or more against an established baseline for comparable projects

A clear project-specific need for project-wide use of materials that do not meet the longevity requirements

W7 ESTABLISH OR SUPPORT MATERIALS REUSE FACILITIES

REUSE PRODUCTS AND MATERIALS

WASTE/CIRCULARITY

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●○○

COST-EFFICIENCY ●●●●○

ENFORCEABILITY ●●●●○

SUMMARY

This policy authorizes the funding and creation of collection and distribution centers for salvaged building materials, which may also serve an expanded role in market research and development as well as the facilitation of networks. These networks could include; contractors experienced in utilizing salvaged materials; deconstruction contractors; developers; designers; and material donors.

VARIANTS

The funding and creation of collection and distribution centers for salvaged materials could be achieved through expansion of existing city supported recycling infrastructure and legislation.

BENEFITS

Supporting the development of robust markets for salvaged and recycled materials will enable and encourage designers, builders and developers to use them as an alternative to newly manufactured materials. This will also reduce waste.

PRE-REQUISITES

No prerequisites have been identified for this policy. However, the implementation must be done in a manner that does not infringe state aid rules. This policy is unlikely to be feasible to implement within the European Union due to State Aid rules.

ENFORCEMENT

City supported or owned material reuse facilities must have management systems that prioritize clear and consistent recordkeeping. The transparency regarding the source and value of salvaged materials and financial transactions, especially when assessors, material donors, and facilities may have financial incentives to inflate valuations of materials are key. All records should be audited by a third party.

W7 - SPOTLIGHT: Pennsylvania

The Pennsylvania Recycling Market Center Incubator and the Recycling Development Center established by the State of Washington's HB 1543 are examples of centers created to facilitate the development of markets for recycled and recyclable materials.

The Habitat for Humanity Restore, which has stores across the United States, and independent architectural salvage yards such as Second Use in Seattle, Washington may serve as models for the physical facilities to collect and distribute salvaged building materials.

W7 - EXAMPLE LANGUAGE

Policy language for the creation of materials reuse facilities can be adapted from existing precedents, such as the State of Washington's HB 1543 (cited above) to refer specifically to building material reuse and recycling. Such language could follow the template below:

Intent: The jurisdiction will create a center to facilitate the recovery, reuse, and recycling of building materials, as well as business assistance, basic and applied research and development, and policy analysis, to further the development of domestic processing and markets for salvaged and recycled building materials and commodities. Therefore, it is the policy of the jurisdiction to create the Center for Building Material Reuse and Recycling to collect, process, and distribute salvaged building materials, as well as to research, incentivize, and develop new markets and expand existing markets for salvaged materials.

Administration: The Center for Building Material Reuse and Recycling will be managed by the Department of [insert appropriate department or office].

Activities: In fulfilling its intent, the center must initially direct its services to businesses that transform or remanufacture reusable materials into usable or marketable materials or products for use rather than disposal. The center will perform the following activities:

- Establish partnerships with existing material reuse facilities or establish a new physical facility for the collection, processing, and distribution of salvaged materials.

- Develop an annual work plan. The work plan must describe actions and recommendations for developing markets for commodities comprising a significant percentage of the building material waste stream.

- Initiate, conduct, or contract for studies relating to market development for recycled and reused building materials, including but not limited to: applied research, technology transfer, and pilot demonstration projects

- Provide grants or contracts to local governments, agencies, or other public institutions to further the development or revitalization of recycling markets in accordance with applicable rules and regulations.

Collaborations: Wherever necessary, the center must work with: material recovery facility operators; public and private sector recycling and solid waste industries; packaging manufacturers and retailers; local governments; environmental organizations; interested colleges and universities; and state/provincial agencies.

W8 CARBON REDUCTION OR SALVAGING REQUIREMENT FOR DEMOLITIONS

REUSE PRODUCTS AND MATERIALS

BUILDING REGULATION, WASTE/CIRCULARITY

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●○○

SUMMARY

For every demolition permit application, require that the applicant demonstrates either how they reduce carbon by demolition and rebuild option vs. maintaining the current building. Alternatively, they could meet mandatory materials salvaging requirements. Applicant must choose the option they will use in their permit application.

VARIANTS

The policy would not apply to any buildings with asbestos or other health harming contaminants, posing other health risks nor it would apply structurally damaged or derelict buildings.

BENEFITS

Preserving existing buildings can help save carbon but does not always guarantee a lower life-cycle carbon impact, if the building is very energy inefficient. This asks the contractor to first identify how they can reduce carbon for the project. And since carbon reductions may not be always be possible to achieve, a secondary compliance path using salvaged materials requirement can be applied instead.

PRE-REQUISITES

City must be able to require environmental performance for demolition permits.

ENFORCEMENT

Enforcement can be done in connection with the application route. Auditing actual outcomes would likely require external auditors to be engaged on a sample project.

W8 - SPOTLIGHT: London, Vancouver, Portland and Norway

London's borough of Camden's Policy CC1 (Climate Change Mitigation) requires all proposals involving substantial demolition to demonstrate that it is not possible to retain and improve the existing building. As such, any proposal to demolish the existing building would need to be fully justified in terms of the optimisation of resources and energy use in comparison with the existing building. Where the demolition of a building cannot be avoided, they will expect developments to divert 85% of waste from landfill and comply with the Institute for Civil Engineer's Demolition Protocol and either reuse materials on-site or salvage appropriate materials to enable their reuse off-site. When comparing the carbon impacts of a new development and a refurbished scheme, the applicant should include comparison with embodied carbon of NEW materials used for renovation and demolition and rebuilt options, including 60 years operational carbon emissions.

Vancouver's demolition permit with recycling and deconstruction requirements provide minimum reuse and recycling requirements when you demolish a house built before 1950. Additionally, a deconstruction requirement applies when you demolish a heritage listed house, or a house built before 1910. The minimum reuse and recycling rates are measured by weight as follows: Houses built before 1950: 75% of materials by weight, excluding hazardous waste. Houses built before 1950 and deemed character houses by the City: 90% of materials by weight, excluding hazardous materials.
Vancouver requires a $14,650 (10 000 EUR/11,000 USD) deposit for a demolition permit with minimum reuse and recycling requirements. The deposit will be refunded if the reuse and recycling requirements are met. If the requirements aren't met, some or all of the deposit won't be returned in accordance with Appendix C of the Green Demolition Bylaw.

The City of Portland, Oregon (US), adopted a deconstruction ordinance in 2016 that requires certain projects seeking a demolition permit to be fully deconstructed as opposed to mechanically demolished. All single-dwelling structures are subject to the Deconstruction Ordinance if the structure was built in 1916 or earlier; or the structure is designated as a historic resource subject to the demolition review or 120-day delay provisions of Title 33.

A Certified Deconstruction Contractor must perform the deconstruction work. The demolition permit requires that a deconstruction contractor be appointed, and they file a Pre-Deconstruction Form, which only certified deconstruction contractors have.

Voluntary guides on alternatives to demolition have been published e.g. in Norway.

W8 - EXAMPLE LANGUAGE

Demolition permits are only granted in following cases:

1. The contractor can show that the demolition and new construction project for which a construction permit is filed at the same time reduce life-cycle carbon by at least 30 % compared to maintaining the existing structure on per square meter of area basis over 60-year period using methodology described in *Life-cycle carbon limits for new buildings*. The applicant must demonstrate this achievement on project completion by submitting a life-cycle carbon performance calculation of the completed building.
2. The contractor commits to minimum 90 % reuse and recycling rate by weight, excluding hazardous waste. The applicant must demonstrate this achievement on project completion by submitting a waste disposal report.
3. The applicant can show that the building contains asbestos or other health harming contaminants, is posing other health risks, or is structurally damaged or derelict.

Applicants pay in a green demolition guarantee which is set at minimum 10 000 EUR ($11,000), or for buildings above 200 m2 (2,150 sq.ft), at 50 EUR per square meter ($5.15 per sq.ft). The green demolition guarantee is returned when the applicant has successfully demonstrated the achievement of the requirements on completion.

W9 MANDATORY CONSTRUCTION AND DEMOLITION WASTE LANDFILL DIVERSION

REUSE PRODUCTS AND MATERIALS

BUILDING REGULATION, WASTE/CIRCULARITY

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●○○○

SUMMARY

A mandatory and enforced landfill diversion rate for construction and demolition waste creates recycling business model that increases waste separation and lower the costs of processing. Targeting renovations can affect non-structural materials, which can be collected separately.

VARIANTS

An alternative are limits of unsorted waste for construction and renovation projects separately.

BENEFITS

This policy spurs the creation of recycling businesses and recovers the waste flows.

PRE-REQUISITES

This policy requires ability to enforce waste handling and local recycling infrastructure. Within European Union, the CDW landfill diversion requirement is at least 70 % in 2020 (2008/98/EC).

ENFORCEMENT

Enforcement, if none is in place, is demanding and will require regional coordination to prevent "leakage" of waste streams to lower cost locations which do not enforce same regulations.

W9 - SPOTLIGHT: San Francisco and Trondheim

San Francisco Ordinance No.27-06 (Construction and Demolition Ordinance) require that C&D debris material removed from a project must be recycled or reused. No C&D debris can be taken to landfill or put in the garbage. The ordinance requires that all mixed C&D debris is transported off-site by a Registered Transporter and taken to a Registered Facility that processes all mixed C&D debris.

Municipal building projects from the city of Trondheim, Norway, sets as the limit maximum 40 kg of waste per square meter of new building, with rules of minimum sorting requirements.

W9 - EXAMPLE LANGUAGE

All new construction projects of at least 200 m2 (2,000 sq.ft) and all refurbishment projects of at least 1 000 m2 (10,000 sq.ft) shall demonstrate end uses other than landfilling for at least 50 % of waste streams. Such end uses may include backfilling, reuse as material, recycling as well as incineration.

13. MUNICIPAL BUILDINGS

M1 SPACE USE AND OCCUPANCY EFFICIENCY

REDEFINE THE SOLUTION

MUNICIPAL BUILDINGS

CARBON IMPACT	●●○○○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●●●	ENFORCEABILITY	●●●●○

SUMMARY

Require detailed program review to optimize space use, and work towards best in class space use efficiency and high occupancy (temporal use) for all city buildings. Implement a mandatory review, prior to initiating a new building project that requires analyzing current space use efficiency and whether renovation of existing spaces alone would allow achieving desired capacity. If it would not, set targets for space use efficiency and occupancy. New or fully renovated buildings where space efficiency is a priority have been able to halve space per user when compared to older, less well-suited buildings with unsuitable and inefficient spaces. Many types of spaces can also be provided for evening users for example hobby groups.

VARIANTS

Reviewing space use efficiency and occupancy rates of existing building stock can help discover opportunities for savings and synergies between city functions, helped by centralizing municipal properties. A city can also turn to the market to lease spaces which cannot be used efficiently.

BENEFITS

Extra capacity discovered may help avoid building at all and have significant capital cost saving potential also when buildings can be made smaller and emit less carbon.

PRE-REQUISITES

Pre-requisite for space use and occupancy efficiency is professional real estate management.

ENFORCEMENT

If a centralized real estate function is in place, the budget management will support very strongly space use efficiency and looking for synergies. Enforcement can be tied to investment planning approval.

M1 - SPOTLIGHT: Finland, Denmark, Netherlands and London

The Finnish governmental buildings organization Senate properties is implementing a space use efficiency program for all its new real estate projects. This is defined in the Proposed Government Premises Strategy 2020, which also benchmarks best practices in space efficiency. Danish government properties for example apply a total cost cap of 5000 EUR / full time employee (FTE) and 21 m2 per FTE. The Dutch government applies also a reduction policy for workstations to 9 per 10 FTE.

University College of London has also defined Space Standards Guidelines for their property portfolio, which aims to (among others) to improve space efficiency and is considered vital in achieving the University's carbon reduction targets.

M1 – EXAMPLE LANGUAGE

Before applying for investment permit, all municipal construction projects shall:

a) Always demonstrate the average space use and occupancy in municipal buildings of the same type in the city level, including the efficiency achieved by the best performing fifth of buildings of the same type;
b) In case of renovations and extensions, demonstrate the space use and occupancy efficiency in the current premises before the project;
c) Demonstrate how the investment project achieve space use and occupancy efficiency equal to the best performing fifth of the buildings of the type; and
d) Specify how the project enables multiple users and increasing occupancy.

M2 EMBODIED CARBON LIMITS FOR NEW & LEASED BUILDINGS

REQUIRE LOW CARBON PRODUCTS

MUNICIPAL BUILDINGS, PROCUREMENT

CARBON IMPACT	●●○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●○

SUMMARY

New and long term leased city buildings can be subject to a cap on the embodied carbon they can emit during their life cycle. Alternatively, the implementation can set a reduction percentage based on a reference building that considers the site conditions and building type.

VARIANTS

Extending this policy to long term and possible shorter-term leases (e.g. modular buildings) allows sending a strong signal for real estate market that if the market wants to have access to the city as a potential customer for some buildings, then those need to be delivered meeting same requirements as city buildings. The lease condition would only apply to buildings that are built for rent and are rented as new. The scope can exclude the underground construction if typology of soil varies very significantly within the city.

BENEFITS

Setting a carbon performance requirement for project in contract phase ensures that they are implemented during the whole duration of the construction project.

PRE-REQUISITES

Carbon literacy within the city organization to the extent that setting requirements can be sensibly followed and enforced in the project.

ENFORCEMENT

Enforcement usually would rely on data reported back by designers and contractor, which the city then withholds right to audit.

M2 - SPOTLIGHT: Trondheim

The City of Trondheim, Norway, requires all buildings built for the city with investment over 20 million NOK (2 M€ or $2,2M) to deliver life-cycle carbon accounting according to requirements set out herein.

The City of Trondheim requires all projects whose investment is over 50 million NOK (5 M€ or $6M) to deliver life-cycle carbon reductions of minimum 30 % over the project's life cycle compared to a Norwegian reference building.

Trondheim municipal buildings requirements specify the following deliverables:

- Deliver reference building calculation at the end of programming phase
- Deliver design phase calculation at end of concept design phase
- Deliver as built calculation as part of handover documents
- Trondheim city shall be given access to the calculation model for reviewing

The requirements are to calculate building life-cycle emissions for materials and energy referring to FutureBuilt guidance and reporting template. FutureBuilt in turn refers to the national NS 3720 standard. Reference building means building with similar geometry and material quantities based on reference building calculated with One Click LCA Norwegian reference building model or equivalent.

M2 – EXAMPLE LANGUAGE

This policy is substantially like the *Life-cycle carbon limits for new buildings,* and the language expressed therein should be easily adaptable for this policy.

M3 USE CARBON AS A CRITERION FOR DESIGN COMPETITIONS

REDEFINE THE SOLUTION

MUNICIPAL BUILDINGS, PROCUREMENT, FINANCIAL

CARBON IMPACT	●●○○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●○

SUMMARY

Setting carbon as an award criterion for design competitions and design & build competitions for city building can improve the proposals and help to find innovative solutions without having to prescribe measures, by encouraging the market to offer them.

VARIANTS

While design competitions have much more impact to reduce carbon than construction tenders, a construction project still influences carbon by material choices, for energy use carbon, the quality of the delivery impacts actual use.

BENEFITS

Market competition on carbon performance has several important advantages. Firstly, it ensures that projects pay attention to carbon impacts from early stages. Secondly, it increases the winning probability of the lowest carbon bids. Lastly, it avoids having to determine and set a specific requirement level, which would also become a de factor carbon floor for projects, if requirement was expressed as a carbon cap.

PRE-REQUISITES

Public procurement regulation allowing the city to use other factors than price in tendering, including environmental performance.

ENFORCEMENT

Enforcement can happen at bid evaluation stage (when calculations can be verified) and at completion stage, when actual achieved outcomes can be verified. Enforcement is very important in the bid evaluation as it affects awarding the tender.

M3 – ACTUAL LANGUAGE: Helsinki

The City of Helsinki design-build procurement of four municipal housing buildings of total 7 000 m2 (75,000 sq.ft) Asetelmanpolku and Asetelmankatu required construction of two wood structure buildings, parking structure and a deck. The award criteria weigh total price and quality with equal weighing, 50 points for each. Within quality, lowest building life-cycle carbon footprint was awarded maximum of 14 points, energy performance, lower than allowed A energy class, was awarded maximum of 6 points and remaining 30 points were awarded from architecture and technical quality. The project also required delivering a fossil fuel free construction site and meet the A energy class.

The technical requirement and the points calculation method was defined as follows:

Building life-cycle footprint
Bidder shall deliver as part of their bid the life-cycle carbon footprint result for both buildings, the common parking structure and the deck above the parking. The carbon footprint shall be calculated by the bidder using One Click LCA software tool. Bionova Ltd shall verify the calculations at the bid evaluation phase. The verification will ensure, that the decisions made by the bidder in the calculation are consistent and do not degrade performance of the building.

The bidder shall follow the minimum requirements set out in the tender documents. The carbon footprint of the foundations shall be assessed in line with the site survey requirements. Assessment period shall be set to 100 years.

The bidders can influence the life-cycle carbon footprint with e.g. following choices

- Heating solution
- Space and structural choices
- Low carbon materials (e.g. low carbon concrete or recycled materials)
- Innovative solutions that reduce amount of materials used
- Efficient exhaust air energy recovery
- Wastewater heat recovery
- Specification of long-lived construction products

The project life-cycle carbon footprint calculation shall be repeated in the design phase prior commencing the construction phase, as well as on completion of construction phase. The retained bidder is responsible for the design phase life-cycle carbon footprint calculation with the One Click LCA software including related license costs. The design phase carbon footprint verification shall be performed by Bionova Ltd at the expense of the retained bidder. The design phase carbon footprint may not exceed the bid phase carbon footprint. The completion phase carbon footprint shall be calculated and verified by Bionova Ltd. The retained bidder is responsible for delivering the necessary information to enable this.

If the entire project (residential buildings, parking structure and covering deck) life-cycle carbon footprint in the completion phase carbon footprint calculation is same or lower than the one calculated in the bid phase, the client shall apply the retained bidder a performance bonus of 50 000 EUR. In case the completion phase carbon footprint calculation is higher than the bid phase carbon footprint, the client has the right to apply a 50 000 EUR contractual penalty to the retained bidder.

The assessment shall be performed in line with European Standard EN 15978 and Ministry of Environment's Method for the whole life carbon assessment of buildings with the following adjustment to the scope of the study: from the site construction only the parking structure and the covering deck are included in the assessment.

The bidder is required to submit, in addition of other documents, the life-cycle carbon footprint separately for each of the four buildings as well as the parking structure and deck calculated with One Click LCA, and as a total result (kg CO2e / m2 net heated area), and a short summary of retained low carbon solutions, including materials and energy where the bidder has deviated from standard solutions. This summary maximum length is two A4 pages.

The client may ask for clarifications in relation to the documentation and reject the life-cycle carbon footprint calculation due to lacking information or clarifications. In such case, the bidder shall get 0 points for life-cycle carbon footprint.

The client organizes for interested bidders a free One Click LCA tool training. The training covers the tool basic functionality and steps for performing the calculation. The bidders wishing to participate to the training are requested to register by email. The bidders may ask questions in connection with the training registration. Interested bidders get free access to the software until closing of the bids, and they shall be provided the necessary methodological requirement instructions. The materials shall be provided to the training participants and can be request by email.

The maximum points for life-cycle carbon footprint is 14 points. The bidder achieving the total lowest life-cycle carbon footprint (as kg CO2e / m2 net heated area) shall get the maximum points. The bidder with the highest life-cycle carbon footprint shall get 0 points. The points for other bids are calculated by interpolation between the minimum and maximum life-cycle carbon footprint as follows: *((bid CFP – highest CFP) / (lowest CFP – highest CFP)) * 14 points*. Points are calculated with two decimals precision.

M4 LOW CARBON SITES, STABILIZATION AND FOUNDATIONS

REDUCE & REPLACE MATERIALS AND STRUCTURES

MUNICIPAL BUILDINGS, INFRASTRUCTURE, BUILDING REGULATIONS

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●○○
COST-EFFICIENCY	●●●●○	**ENFORCEABILITY**	●●●●○

SUMMARY

Underground construction can be very carbon intensive. Set a mandatory pre-design evaluation for each project before site is decided. Before the site for a new municipal project is chosen, the carbon impacts resulting from the soil type and depth should be analyzed. Furthermore, 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. Soil improvement on poor land can be very expensive per built square meter.

VARIANTS

This type of policy could be extended in some form to building regulations or via bonus systems, as a financial policy. The same foundation issues should be also considered when new infrastructure is built by the city.

BENEFITS

Soil stabilization and foundations will cause a great demand for cement, quicklime and steel which are all very carbon intensive materials. Making the choices on underground construction early avoids/can avoid altogether some of the highest impact options.

PRE-REQUISITES

No prerequisites have been identified for implementing this policy for municipal buildings.

ENFORCEMENT

This policy implementation can be managed via the investment process.

M4 - SPOTLIGHT: Norway and Helsinki

Statsbygg, the Norwegian government property arm, considers for each new public building typically 5-7 implementation alternatives in a very early phase. These options are also evaluated for the type of the soil on the sites, among other major carbon impact causing parameters such as energy supply and transport impacts. This allows making an informed decision at very early phase.

The City of Helsinki, Finland, is presently making a network analysis considering also these options for some service buildings. This is not however a standard policy yet. The soil improvements in some new districts in Helsinki have cost the municipality 1-1,4 M€ per hectare ($430-600k per acre), which in these districts was equaled to 245-314 € per m2 ($29-37 per sq.ft). While these costs/works can't be fully avoided, they can be reduced.

M4 – EXAMPLE LANGUAGE

Cities may use the following examples to develop their requirements for projects.

Before proposing a site for any municipal building of at least 400 m^2 (4400 square feet), the project team shall take into consideration the prevailing soil conditions for the building site as well as the cost and carbon impact of foundations.

When possible, priority most be given to positioning of the building mass to benefit from a site's underlying soil characteristicsto reduce the carbon from it's foundations.

All municipal construction projects requiring sheet piling for pit excavation protection shall require removing and reusing the sheet piling at the end of the contract.

All municipal construction projects requiring pilling shall examine piling designs and materials based on their carbon intensity and apply the most low-carbon option.

All municipal construction projects requiring deep mixing shall not use CEM I cement or to the extent possible, any types of cement. Projects shall actively search for cement free or low cement alternatives for stabilization.

All municipal construction projects requiring soil stabilization shall implement soil stabilization where at the minimum 50 % of cement and quicklime used for soil stabilization is replaced with alternative binders, such as ground granulated blast furnace slag (GGBS), fly ash, biochar or other geopolymers.

M5 PUBLICIZE BEST PRACTISES AND CASE STUDY PROJECTS

REQUIRE LOW CARBON PRODUCTS 

MUNICIPAL BUILDINGS OR ALL CATEGORIES  & all

 **CARBON IMPACT** ●○○○○

 **IMPLEMENTABILITY** ●●●●●

 **COST-EFFICIENCY** ●●●○○

 **ENFORCEABILITY** ●●●●●

SUMMARY

Establish a commitment by the jurisdiction to publicize best practices for, and case study projects demonstrating, significant embodied carbon reductions.

VARIANTS

Publicity on best practices and case study projects can be drawn from:

- municipal building projects subject to municipal building embodied carbon reduction policies such as those described in this report

projects that receive a density bonus, tax rebate, expedited or reduced fee permitting or other incentive for embodied carbon reduction as described in this report

BENEFITS

Case studies and publications that provide an overview of best practices for reducing embodied carbon serve both practical and inspirational purposes. High-profile, successful projects that publicly emphasize embodied carbon reduction strategies serve to elevate the topic of embodied carbon, paving the way for policies and sector wide change, while also demonstrating the benefits of low carbon design choices. Access to educational materials lowers the informational barriers for designers, builders and developers to implement embodied carbon reductions. Additionally, increasing awareness of the potential cost savings that accompany measures to reduce waste and/or reuse existing buildings creates a financial incentive for developers and property owners.

PRE-REQUISITES

No prerequisites have been identified for this policy.

ENFORCEMENT

No enforcement is necessary for this policy.

M5 - SPOTLIGHT: Oakland, Minnesota, King County

Oakland, California, Minnesota, and King County, Washington have published case studies on green building projects and practices, some of which highlight measures taken to reduce embodied carbon.

M5 – EXAMPLE LANGUAGE

The process for creating and publicizing materials on embodied carbon reduction case studies as well as best practices could follow the template below:

Intent: It is the intent of the City to publicize best practices and case study projects that demonstrate a significant embodied carbon reduction.

Program: To accomplish this goal, the City will allot staff time as well as funds to the creation and publication of case studies and best practices.

Allocation of resources: The City will allot funds to this program in the amount of [$X] per year for the hiring of consultants and educators to create and distribute materials.

Appointment of personnel: The City will appoint an office, internal resource centre, or coordinator position to manage the creation as well as publication of case studies and best practices.

M6 RENOVATION VS. KNOCK DOWN AND REBUILD COMPARISON

REFURBISH EXISTING ASSETS

MUNICIPAL BUILDINGS, BUILDING REGULATION, WASTE/CIRCULARITY

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●○

SUMMARY

Many city buildings require renovation, at times very costly, which leads to considering knockdown and rebuild options. Both options can be compared in means of life-cycle carbon (including energy) as well as reuse and salvaging options to decide. The decision can also consider life-cycle costs to make sure approach is sound for long term finances. This would not be required for buildings that can cause health risk or that are damaged.

VARIANTS

If a knockdown and rebuild is chosen, apply pre-demolition audit and minimum salvage requirements. Also, apply the minimum salvaged materials requirements to the replacement building. This type of policy could also be applied to rezoning requirements where an applicant proposes to rebuild the buildings.

BENEFITS

Property portfolio is typically a significant portion of the city assets. It is therefore essential to ensure that those investments are carbon and cost efficient. Comparing life-cycle carbon and cost allows making tradeoffs with improving energy performance and investments in materials as well as renovating existing vs. building new.

PRE-REQUISITES

No pre-requisites have been identified. Cities hold the right to manage their property.

ENFORCEMENT

This is managed via the investment process. Enforcement should apply to renovation category within the city's investment process.

M6 - SPOTLIGHT: Lahti

The City of Lahti (Finland) applied the life-cycle carbon and life-cycle cost performance methodology to decide about demolition and rebuild vs. renovation for two schools called Jalkaranta and Liipola of approximately 8 000 m2 (86 000 sq.ft) each. Both projects also included extensions, changes in spaces and some to the usage.

The city's real estate department calculated internally the life-cycle carbon footprints for both projects using a 50-year lifetime, district heat supply of the city (which considered an imminent waste incineration investment), and BIM models provided by the designers. The calculation was made in 2014 using One Click LCA, the then current European Standard EN 15978 and Green Building Council Finland's Building Life-Cycle Metrics guidance. In line with the methodologies prevailing at the time, the calculation did not consider degressive energy supply carbon emissions.

In both cases, the demolition and rebuild options had significantly lower life-cycle carbon footprint as well as life-cycle cost, and those options were implemented.

M6 – EXAMPLE LANGUAGE

All municipal projects, where a demolition and rebuild option is proposed, must consider also a renovation option. The renovation option must achieve comparable use as the new building, or an alternative equally valuable use.

Both options must demonstrate having calculated life-cycle carbon footprint in line with the European Standard EN 15978, or a comparable national methodology. Where national methodology does not provide more detailed guidance, the calculation shall cover:

- Operational energy as per applicable building regulations, matching the calculated and reported energy performance calculation, using the energy emission factors issued in the national methodology.
- Construction materials for sub- and superstructure, building envelope, foundations and parking structures (omitting finishes and services).
- The minimum required life-cycle modules are A1-A3 Construction materials, B4-B5 Replacement of materials in use, B6 Operational Energy, and C1-C4 End of life. The calculation shall not deduce the end of life benefits (D).
- If the used energy carbon emission factors are not degressive in function of time, the assessment shall be performed for calculation period of 30 years. Otherwise, the assessment shall be performed for a period of 60 years.
- Methodological compliance and choices as well as used key data are reported as part of the conclusions.

Projects may also complete a life-cycle cost calculation in line with ISO 15686-5, or a comparable national methodology, for a 60-year period using a 3 % discount rate and energy inflation forecast of 4 % and general inflation forecast of 2 %.
Both the renovation and rebuild option shall be compared for the functionality they deliver and not per built area basis. The capacity shall be defined based on type of building as number of homes, occupants, customers or another appropriate unit.
The rebuild option may be retained only if it demonstrates a life-cycle carbon reduction. If the rebuild option is retained, it shall be required deliver a full pre-demolition audit. Also, to salvage at least 5 % of materials (by mass) from the demolished building and use at least 5 % of salvaged or reused materials (by mass) in the new building.

This policy shall not apply to buildings that contain dangerous substances or have been declared unfit to occupy due to health hazards (e.g. due to actinomycete).

M7 SALVAGED, REUSED OR RECYCLED MATERIAL MINIMUMS

REUSE PRODUCTS AND MATERIALS

BUILDING REGULATION

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●○○

SUMMARY

This regulation requires all municipal construction projects to meet minimum requirements (set by project or material type) for the use of salvaged, reused or recycled materials.

VARIANTS

Non-municipal projects that meet these requirements could be eligible for incentives.

BENEFITS

Implementing consistent criteria and procedures for the use of reused, recyclable and recycled products and materials in municipal building and infrastructure projects will:

- Reduce the embodied carbon
- Support regional supply chains for salvaged, reused, and recycled material

Create useful examples and pathways for non-municipal projects to follow to utilize salvaged, reused or recycled materials.

PRE-REQUISITES

City or county must have defined criteria for what constitutes salvaged, reused or recycled material.

ENFORCEMENT

This policy can be enforced by the authorities that oversee and enforce existing procurement rules.

M7 - SPOTLIGHT: Los Angeles

Los Angeles County's Metropolitan Transport Authority (Metro), through their Construction Demolition Debris Recycling and Reuse Policy, requires that Metro gives preference to recyclable and recycled products in the selection of construction materials to the maximum extent feasible during design and construction of Metro or Metro-funded capital projects.

M7 – EXAMPLE LANGUAGE

Procurement rules and/or guidelines establishing minimum requirements (set by project or material type) for the use of salvaged, reused or recycled materials can be adapted from existing procurement guidelines, such as the example of Los Angeles County Metropolitan Transport Authority or alternatively could follow the template below:

Intent: This policy is to maximize the use of salvaged, reused or recycled materials in municipal construction projects of all kinds, thereby reducing the embodied carbon of municipal construction projects.

Requirements: The jurisdictional procurement authority must give preference to salvaged, reused and recycled products in the selection of construction materials to the maximum extent feasible throughout the design and construction of all projects. Selected materials used in the construction of all structures should not adversely affect the performance or safety of the system or structure for which the material is used.

Exemptions: Projects that demonstrate one of the following may be exempt from this policy:

- Embodied carbon reduction of [xx%] or more against an established baseline for comparable projects
- A clear project-specific need for project-wide use of materials that are not available in a recycled form

14. FINANCIAL

F1 TAX REBATES FOR LOW CARBON DEVELOPMENTS

REQUIRE LOW CARBON PRODUCTS

FINANCIAL POLICIES

CARBON IMPACT ●●○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●●●

ENFORCEABILITY ●●●●○

SUMMARY

A jurisdiction can offer an annual property tax rebate of up to 100% for a set number of years to property owners who build new projects that meet specified embodied carbon criteria or owners who opt for low-carbon reuse/renovation rather than new construction. The amount of the rebate can be based on a quantification of the embodied carbon reduction, so that projects with greater relative embodied carbon reductions are eligible for larger rebates.

VARIANTS

-

BENEFITS

By providing a significant financial incentive to property owners to reduce embodied carbon in projects on their properties, the jurisdiction can accelerate embodied carbon reductions and support low-carbon construction projects that may serve as models for local innovation.

PRE-REQUISITES

The jurisdiction must have authority and administrative capability to exercise discretion over property tax rebates.

ENFORCEMENT

This policy can be enforced by the authorities that oversee existing tax rebate programs. Regular audits can ensure that only projects that fully comply with the embodied carbon requirements set out in the policy receive the tax rebate.

F1 - SPOTLIGHT: Milford, Netherlands, Romania

The City of Milford Property Tax Rebate Program in Milford, Connecticut establishes that any new commercial or industrial business relocating or establishing operations in the City of Milford is eligible to receive an annual rebate of up to one hundred percent (100%) for five years for city property tax collected. To qualify for the rebate, an enterprise must meet one of the criteria set out, which include a minimum capital investment including construction, relocation from another area outside the city, or classification in a preferred industry sector. Alternative criteria could be designed for a tax rebate program incentivizing low-embodied carbon construction.

The Dutch government has also introduced tax policy measures, including faster depreciation of environmental investments (up to 75 % in first year), and a further tax rebate for purchase of assets having high performance using the Environmental List. The budget for the tax rebate is set at 114 million euros for year 2019. The Environmental List is a collection of pre-validated measures that render projects eligible to seek tax rebates.

Several Romanian cities provide property tax rebates for green building certification. However, those are not directly linked to carbon impacts.

F1 - EXAMPLE LANGUAGE

Intent: A tax rebate is created with the intent to incentivize low-embodied carbon construction and adaptive reuse as an alternative to new construction.

Eligible buildings: A project must demonstrate embodied carbon reduction of [xx%] or more against an established baseline, per square foot, square meter, or dwelling unit, for comparable building types.

F2 INCREASED PROPERTY TAX FOR UNOCCUPIED PROPERTIES

REDEFINE THE SOLUTION

FINANCIAL ACTIVITIES

CARBON IMPACT ●●○○○

IMPLEMENTABILITY ●●●○○

COST-EFFICIENCY ●●●●●

ENFORCEABILITY ●●●●○

SUMMARY

Unoccupied buildings (in good condition or otherwise) that remain unoccupied require equivalent amount of new construction to provide the same space and services to citizens and businesses. This leads directly to more new construction and thus carbon emissions. Imposing a significant additional property tax on properties occupied less than 50-100 days per year provides a strong incentive for owners of such properties to let them out, sell them, or renovate them in order to be able to do either, thus increasing the supply with less carbon.

VARIANTS

An approach could target only residential buildings and/or business properties. In addition, this type of taxation can also target hotel-like business operations whose basis of business is a platform-shared short-term renting of the apartments.

BENEFITS

This is a fiscally positive measure and may support availability of housing stock.

PRE-REQUISITES

Enabling legislation in place which allows targeting tax increases based on occupancy.

ENFORCEMENT

Enforcement would likely need or greatly benefit from having information on general income tax of the residents in the apartments and that would need to be correlated with records of addresses and other supporting information. This would require each taxable property to declare and demonstrate their status. However, considering results have fiscally positive impacts such costs should be bearable.

F2 - SPOTLIGHT: England, Wales), Vancouver and US

Enabling legislation for second homes and empty properties taxation is in place in England and Wales where council tax can be doubled if home has been empty for 2 years or more.

Vancouver's Empty homes tax was shown to have reduced empty homes by 15 % in Vancouver between 2017 and 2018. Properties deemed empty will be subject to a tax of 1% of the property's 2019 assessed taxable value (1,25 % in 2020). Properties used as a principal residence by a permitted occupier for at least six months of the 2019 tax year, or rented for residential purposes for at least six months of the current year, in periods of 30 or more consecutive days, or those otherwise exempt do not pay this tax. Other US cities are applying similar practices.

Catalonia sets also a special tax rate for any unoccupied properties that have been empty for more than 2 years without a justifiable reason. Financial proceeds from this are allocated to housing plans.

F2 - EXAMPLE LANGUAGE

All residential properties in the city must submit no later than within 60 days of end of tax year a residential property occupancy declaration. The residential property occupancy declaration is used to assess the applicability vacancy tax.

Each residential property's base rate for property tax is multiplied by three, if the property cannot demonstrate to have been occupied on a long-term basis for at least 180 days in the tax year as a principal residence of the occupants. Each rental agreement applied during the tax year towards these 180 days must be at least 30 days long and must be with a person registered as a resident in the city.

City may further define cases for exemptions in case of e.g. decease of the resident during a tax year, should their property tax system allow exemptions.

F3 LINK LAND USE FEES TO PROJECT LIFE-CYCLE CARBON

REDEFINE THE SOLUTION

FINANCIAL ACTIVITIES

CARBON IMPACT	●●○○○	IMPLEMENTABILITY	●●○○○
COST-EFFICIENCY	●●●●●	ENFORCEABILITY	●●●○○

SUMMARY

Cities often charge land use fees from projects. These fees could be indexed to project embodied carbon. The charge structure could also be set up so that very low carbon projects would not pay fees at all or be possibly eligible for cash refunds.

VARIANTS

Building additional floors to existing buildings can increase density but this is notoriously hard to make happen. A tax break on property tax could provide necessary impetus, while increasing taxable building base to offset the discount in the long term. For smaller buildings a set of prescriptive choices could be used instead of calculations.

BENEFITS

Linking land use fees to the carbon performance is a very direct and easily understood incentive that the investor or developer can act on. If the land use fee can become a bonus, it may effect market behavior even more.

PRE-REQUISITES

The city must be able to set fees for land use at its discretion and vary them between different projects based on performance criteria.

ENFORCEMENT

For large buildings, the enforcement could be based on a third party verifying the results on completion. If the verification only concerns embodied carbon, enforcement can take place on completion. If the verification concerns also operational energy, result would be more reliable if the building was in use for two years before the final audit, as operating energy consumption in the first year of use is not yet stabilized.

F3 - EXAMPLE LANGUAGE

Land use fees assessed for projects shall be established based on project life-cycle carbon intensity per square meter relative to building type benchmark. Project life-cycle carbon intensity per square meter is assessed using methodology and scope defined by the city. The life-cycle carbon intensity for project shall be verified by a competent verifier. Any projects with unverified or undocumented emissions shall be assessed for land use fees with a multiplier of 1,5.

Land use fee per square meter is multiplied with figure achieved as follows:

Project carbon intensity is below 0,5 of benchmark: multiplier is 0,2
Project carbon intensity between 0,50-0,70 of benchmark: multiplier is 0,5
Project carbon intensity between 0,70-0,90 of benchmark: multiplier is 0,8
Project carbon intensity between 0,90-1,10 of benchmark: multiplier is 1,0
Project carbon intensity between 1,10-1,30 of benchmark: multiplier is 1,2
Project carbon intensity between 1,30-1,50 of benchmark: multiplier is 1,4
Project carbon intensity is above 1,5 of benchmark: multiplier is 1,5

F4 CARBON PERFORMANCE GRANTS FOR PROJECTS

REQUIRE LOW CARBON PRODUCTS

FINANCIAL POLICY

CARBON IMPACT ●●○○○

IMPLEMENTABILITY ●●○○○

COST-EFFICIENCY ●●●●●

ENFORCEABILITY ●●●○○

SUMMARY

Cities can set aside funds to award performance-conditioned grants for projects that achieve a clearly above market embodied carbon performance. Grants can be applied for during planning permission application, but they would be paid out only once project is completed, and performance achieved is possible to verify and audit.

VARIANTS

Grants can be fixed amounts, a menu of cash for measures or sliding performance scale so that better performance makes a project eligible for higher grant amounts.

BENEFITS

Grants allow easy introduction of embodied carbon policies and increases knowledge on the market. This enables a smoother introduction to actual non-voluntary requirements as a next step.

PRE-REQUISITES

The city must be able to provide grant incentives for performance without that being against State Aid legislation and city must be able to budget the funds.

ENFORCEMENT

Enforcement can happen via a third-party verification report that is submitted to the building supervision, or with building supervision's resources if such are available. Alternatively, the city organization disbursing the funds can set up inspection directly.

F4 - SPOTLIGHT: Douro-Dummer and Voralsberg

The township of Douro-Dummer (Ontario, Canada), Sustainable Development Guidelines 2020, provides 50 first applicants after March 1st, 2020 opportunity to apply for a block grant for projects whose carbon emissions are below the fixed target. The planned program outline is to reward builders for meeting a fixed threshold with a grant of $10,000 (Canadian dollars) per house that meets the requirements. As the grant application is not open yet, the final threshold values are not set. The construction will be measured in accordance with defined criteria and the associated Carbon Calculator from Builders for Climate Action. The up-front carbon emissions of the buildings are divided by eligible floor area. Foreseen cap is thought to be 75 kgCO2e/m2. There are additional requirements for building operational performance as well.

The Austrian state of Voralrberg provides grants for low operating or embodied carbon new houses. For example, a wood-cladding grant is 20 €/m2 and renewable insulation is 30€/m2. Austrian national embodied impact system classifies building impacts using an index called ÖkoIndex, which considers environmental impacts of materials, including carbon. Buildings exceeding ÖkoIndex Level 3 are eligible for an additional grant of 150 €/m2. Materials deemed harmful to the climate are prohibited from projects receiving grants. The maximum size of a project that grants cover is 110 m2, and the grants are limited to lower income classes, thus they are part of social housing grants. In addition, projects meeting the criteria are eligible for inexpensive loans. In total, six out of nine Austrian states have similar systems. Altogether, over 500 projects have received these grants.

F5 INCLUDE EMBODIED CARBON IN CLIMATE ACTION PLAN

REDEFINE THE SOLUTION

FINANCIAL POLICY, MUNICIPAL BUILDINGS, INFRASTRUCTURE, PROCUREMENT

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●●
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●●

SUMMARY

Require all future climate action plans or updates to existing climate action plans, to include an assessment of embodied carbon emissions from building and infrastructure construction, transportation, and land use. Also, to include a timeline and strategies for meeting reduction targets for embodied carbon in conjunction with timelines for reducing operational emissions.

VARIANTS

No variants have been identified for this policy.

BENEFITS

Addressing embodied carbon in climate action plans supports jurisdictions in understanding the magnitude of embodied carbon emissions within their boundaries in addition to elevates the public discourse and understanding of the importance of embodied carbon. This makes it more likely that further policies for embodied carbon reduction will be implemented within a consistent climate action policy framework.

PRE-REQUISITES

There are no prerequisites for this policy.

ENFORCEMENT

Enforcement is not required for this policy.

F5 - SPOTLIGHT: San Francisco, Boston

Many cities have existing climate action plans, but only a few examples have been identified that address embodied carbon at all. No examples of plans that integrate embodied carbon significantly, and elevate it to a central concern, have been identified. A progress report on San Francisco's climate action plan includes a mention of embodied carbon, but does not address it in depth. The 2019 update to Boston, Massachusetts', climate action plan includes several references to measures the city can take to reduce embodied carbon, but it does not include in-depth analysis or a timeline for meeting embodied carbon reduction targets.

F5 - EXAMPLE LANGUAGE

Intent: The intent of this policy is to support jurisdictions in understanding the magnitude of embodied carbon emissions within their boundaries, elevate the public discourse and understanding of the importance of embodied carbon in addition to make it more likely that further policies for embodied carbon reduction will be implemented within a consistent climate action policy framework.

Requirement: All new climate action plans or updates to existing climate action plans must fully integrate considerations of embodied carbon. Climate actions plans should include analysis of current annual embodied carbon emissions, set timelines for meeting embodied carbon reduction targets as well as identify measures, mechanisms, and policies to achieve embodied carbon reductions.

F6 INCREASE DEMOLITION PERMITTING FEES

REFURBISH EXISTING ASSETS

FINANCIAL POLICIES, BUILDING REGULATIONS

CARBON IMPACT	●○○○○	**IMPLEMENTABILITY**	●●●●○
COST-EFFICIENCY	●●●○○	**ENFORCEABILITY**	●●●●○

SUMMARY

Increase demolition permitting fees for property owners applying to demolish buildings. Such increases could be applied conditionally, depending on building age, building size, predominant materials, carbon efficiency of the proposed replacement project, suitability of the building to deconstruction or other variables.

VARIANTS

This policy can be made more impactful with a refundable deposit.

BENEFITS

Increasing barriers to demolition incentivizes for adaptive reuse and deconstruction. By charging more for demolition proposals, the city can encourage more property owners to seek alternatives to demolition that are low carbon, including material reuse and recycling and adaptive reuse.

PRE-REQUISITES

The jurisdiction must have authority over permitting processes and the ability to impose permitting fees. Also, they must be relatively free to set their fees or parts thereof.

ENFORCEMENT

No separate enforcement is necessary for this policy; fees are collected in the same manner.

F6 - SPOTLIGHT: Marin County

Marin County supervisors approved an ordinance in October of 2019 to increase building permit fees by an average of 50%, as well as an attendant technology fee increase of 1%, with the cost of demolition permits increasing more than the costs of other kinds of permits. The ordinance also authorizes the community development agency director to increase permit fees by 3% annually in future years to account for inflation. No examples of increases in demolition fees for reasons beyond compensation for inflation or rises in administrative costs have been identified.

F6 - EXAMPLE LANGUAGE

Intent: The intent of this policy is to incentivize adaptive reuse or deconstruction of buildings as an alternative to demolition by increasing the fees associated with demolition permits.

Requirements: Applicants for demolition permits must pay a fee of [$X.X], or an [X%] premium, to the Department of [insert appropriate department or office], in addition to the existing base permit application fee.

Exemptions: Buildings that pose an immediate safety or health hazard to their surroundings and demonstrate that they are not candidates for reuse or deconstruction, are eligible for exemption from the additional fee.

F7 INCENTIVES FOR MANUFACTURERS TO REDUCE CARBON

REQUIRE LOW CARBON PRODUCTS

FINANCIAL POLICY

CARBON IMPACT ●○○○○

IMPLEMENTABILITY ●●●●○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●●○

SUMMARY

This policy would create incentives for manufacturers located in the region of the jurisdiction to reduce embodied carbon in their products. Possible pathways include:

- Property/council tax rebates for manufacturers within the jurisdiction that demonstrate and quantify significant embodied carbon reductions in their main products.
- Property/council tax rebates for manufacturers within the jurisdiction who meet a Zero Net Carbon standard for the operation of their facilities, either by generating enough renewable, non-GHG emitting energy on-site to power their manufacturing processes, or procuring renewable, non-GHG emitting energy generated off-site.
- Direct grants/rebates for manufacturers for completing facility upgrades that significantly reduce carbon emissions, such as switching from a material or emissions intensive manufacturing process to a less material or emission-intensive alternative, or installing on-site renewable, non-GHG emitting energy generation.

Dedication of government resources and/or staff time to building relationships and facilitating the development of networks of manufacturers to support industrial symbiosis.

VARIANTS

The incentive structure could be modeled after any other incentive policy described in this report, such as the Density Bonus for Carbon Efficiency or the Property Tax/Council Tax Rebate for Low-Carbon Developments.

BENEFITS

Creating incentives for manufacturers within the jurisdiction to reduce the embodied carbon of their products and the operational emissions of their facilities as well as manufacturing processes will reduce total emissions, both embodied and operational, of the jurisdictional area, as well as bolstering a lower-embodied carbon economy.

PRE-REQUISITES

Compliance with the requirements of the policy must be verified, through building inspection or provision of documents to the administrative authority, before the incentive is awarded.

ENFORCEMENT

No prerequisites have been identified for this policy. However, the implementation must be done in a manner that does not infringe state aid rules, especially in EU

F7 - EXAMPLE LANGUAGE

This policy would create incentives for manufacturers located in the region of the jurisdiction to reduce embodied carbon in their products. Possible pathways include:

- Property/council tax rebates for manufacturers within the jurisdiction that demonstrate and quantify significant embodied carbon reductions in their main products.
- Property/council tax rebates for manufacturers within the jurisdiction who meet a Zero Net Carbon standard for the operation of their facilities, either by generating enough renewable, non-GHG emitting energy on-site to power their manufacturing processes, or procuring renewable, non-GHG emitting energy generated off-site
- Direct grants/rebates for manufacturers for completing facility upgrades that significantly reduce carbon emissions, such as switching from a material or emissions intensive manufacturing process to a less material or emissions intensive alternative, or installing on-site renewable, non-GHG emitting energy generation.

Dedication of government resources and/or staff time to building relationships and facilitating the development of networks of manufacturers to support industrial symbiosis.

F8 LANDFILL TAX ON CONSTRUCTION AND DEMOLITION WASTE

REUSE

FINANCIAL POLICY, WASTE AND CIRCULARITY

CARBON IMPACT	●○○○○	IMPLEMENTABILITY	●●●●○
COST-EFFICIENCY	●●●○○	ENFORCEABILITY	●●●○○

SUMMARY

Tax all landfilled construction and demolition waste. Landfill tax will provide a broad financial incentive to avoid final disposal of all types of material streams. To have impact on construction and demolition waste, this must also be levied on aggregates.

VARIANTS

Alternative is a refundable materials recycling deposit applied for demolitions. It is refundable on demonstrated demolition audit and record of material deliveries.

BENEFITS

Enforced taxation would provide visibility of a long-term revenue stream for recycling plants to be established. Could also lead to more vigorous enforcement and closing of unofficial landfills. While this policy is a powerful one, the City may be a too small unit to execute and enforce a landfill tax without significant tax avoidance.

PRE-REQUISITES

Legal authority to levy a tax and to control transports of waste out of the city

ENFORCEMENT

The City must be able to levy a landfill tax, and at the same time, effectively prevent waste being transported out of the city boundaries to other cheaper unregulated locations to be landfilled there.

F8 - SPOTLIGHT: Europe

In Eastern Europe, landfill taxes vary between 2,7 EUR to 29,8 EUR per ton ($2,9 to $32]. In Northern Europe, landfill taxes vary between 54 EUR to 112 EUR per ton ($58 to $120). Almost without exception, landfill taxation in Europe is a nationally set tax. In some countries the municipalities collect the proceeds, but rates are set nationally.

REFERENCES

In addition of several dozen individual publications, following resources in particular have been used extensively in the preparation of this report.

Bionova Ltd: The Embodied Carbon Review – Embodied Carbon Reduction in 100+ Regulations and Rating Systems Globally

Global Alliance for Buildings and Construction: 2019 Global Status Report for Buildings and Construction

World Green Building Council: Bringing embodied carbon upfront: Coordinated action for the building and construction sector to tackle embodied carbon

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.

Bionova Ltd is a firm of construction carbon specialists operating globally out of Finland. Bionova 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/.

Architecture 2030's mission is to rapidly transform the global built environment from the major contributor of greenhouse gas emissions to a central part of the solution to the climate crisis. For more information: www.architecture2030.org.