Communicating the Importance of

Embodied Carbon and Bio-based Materials

in the Built Environment

Factsheets

CNCA
CARBON NEUTRAL CITIES ALLIANCE

Laudes Foundation

What is Embodied Carbon?

According to the International Energy Agency, buildings and construction are responsible for 39% of global carbon emissions. With urbanisation still rising, it is projected that global new construction will equal the building of one New York City every month for each of the next 40 years. By 2050, around 2.5 billion more people will be living in cities. Quite clearly, this will require vast amounts of building material, as well as enough energy to produce, transport and construct these additional urban environments.

When we think about carbon from the construction sector, it's mainly in terms of "operational carbon" - the carbon associated with the energy we use to keep our buildings comfortable: warm, cool, ventilated and well lit. Operational carbon contributes to 28% of global carbon emissions. But to tackle the construction sector's true footprint, we have to start thinking about the remaining 11% of global emissions. This is known as "embodied carbon".

Embodied carbon means all the CO_2 emitted in production of the materials used in buildings. This includes the energy used to extract and transport all the raw materials as well as the emissions (both energy-related and process emissions) from manufacturing and refining.

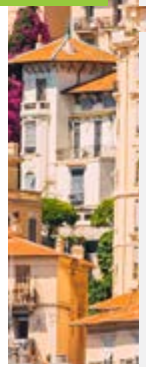
When we talk about the embodied carbon in buildings, this refers to all the CO_2 emitted from the construction process, including:

- The Mining of raw materials.
- The Supply chain emissions involved in transport.
- The building process itself.
- The fixtures and fittings inside the building.
- The emissions associated with deconstruction and disposal.

Why does embodied carbon matter?

According to the International Energy Agency, buildings and construction are responsible for 39% of carbon emissions already today. But as businesses and homeowners adopt clean energy alternatives to fossil fuels, the embodied carbon of buildings is beginning to account for a greater share of global carbon emissions. If we don't address embodied carbon emissions, by 2060, embodied carbon emissions may exceed 230 gigatons, which is more than six years of current (2022) global emissions from fuel combustion.

39% Buildings and construction are responsible for 39% of carbon emissions already today.



If we don't address it, by 2060 embodied carbon emissions may exceed 230 gigatons, which is more than six years of current global emissions from fuel combustion.

How does embodied carbon fit into cities' plans for net zero?

It's important that we take action on embodied carbon emissions now in plans for new buildings and infrastructure – as (quite obviously) the buildings we put up in the coming years will not only still be with us in 2050, but likely to contribute to a huge amount of our current emissions (at least 11%). This is happening at a time when annual global emissions need to be falling at a rate of around 7% per year, according to the UN Environment Programme, for us to have any chance of staying below the 1.5 degree average rises enshrined by the Paris Agreement of 2015.

Right now, "embodied carbon" isn't a phrase in common use in conversations about green development – as this analysis of the English language media shows. To start tackling its emissions, it is crucial that a life cycle carbon assessment is carried when a new building project is in its planning stages. Organisations such as Architecture 2030, Structural Engineers 2050 Challenge (SE2050), the Carbon Leadership Forum, and the World Green Building Council are taking the lead on addressing the issue, and CNCA is working to support cities to lock in long-term change and see embodied carbon form part of local government agendas.

CURRENT

11%

The buildings we put up in the coming years will not only still be with us in 2050, but likely to contribute to at least 11% of our current emissions.

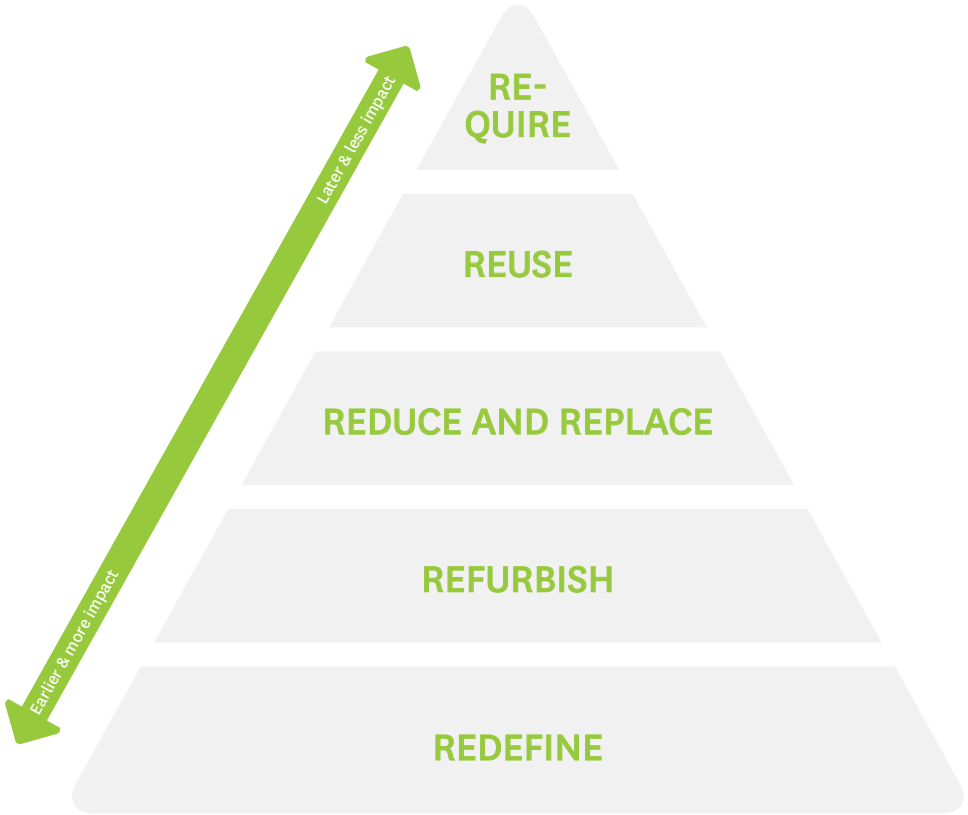
GOAL

7%

Annual global emissions need to be falling at a rate of 7% per year, according to the UN Environment Programme to stay below the 1.5 degree goal.

How can we reduce the carbon embodied in our buildings?

The Carbon Neutral Cities Alliance (CNCA) has identified five different tactics cities can deploy in order to reduce embodied carbon:



1. **Redefine the solution**, to address needs by means other than construction, or by implementing measures that have result to net carbon reductions.

2. **Refurbish existing assets.** This reduces total materials use, and can be a powerful decarbonisation strategy, where it does not compromise energy efficiency.

3. **Reduce and Replace** materials and structures by design and use lower carbon structures and materials where appropriate.

4. **Reuse** products and materials, at end of life for additional uses for unused products from sites and for salvaged materials from refurbishments and demolitions.

5. **Require low carbon products**

1. Redefine the solution, to address needs by means other than construction, or by implementing measures that have result to net carbon reductions.

It's important to reconsider whether additional material use is actually needed as part of the solution. If a public service, such as a leisure centre or health centre is underused, consider options other than renovation, such as improving local transport links to the venue.

In Tampere, Finland, for example, a plot was sold for the construction of a hotel and a life-cycle carbon analysis of proposals was used – in part – to decide which proposal would win the development project. The final project achieved overall lifecycle carbon savings of over 25%.

Similarly, cities are turning to green space and additional tree planting to reduce the temperature of public places, rather than relying on more concrete structures and/or air conditioning. An example is Budapest, Hungary, where about 10,000 trees were planted in urban areas between 2016 and 2019 as part of a program to create shades and increased flood and stormwater management.

Another option is to define procurement in a way that ensures that the market will either certainly or very likely deliver a "circular" solution. Along these lines, in 2018, Lille adopted a scheme to promote socially and environmentally responsible public procurement, identifying actions aimed at preventing the production of waste. As a result, the Maillerie district, a former warehouse site, is being transformed into a mixed-use neighbourhood using a "zero waste" approach: the existing buildings represented 30,000 tonnes of concrete to be demolished, 10,000 m² of oak flooring, 4,500 of light fixtures and several kilometres of shelving. After extensive work and careful removal, the materials were given a second life, reused on site and/or recovered by associations or other manufacturers.

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

2. Refurbish existing assets. This reduces total materials use, and can be a powerful decarbonisation strategy, where it does not compromise energy efficiency.

Much more is being done to repurpose old buildings rather than demolishing them.

For instance:

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

An example here is the City of Lahti (Finland), which applied the life-cycle carbon and life-cycle cost performance methodology to decide between demolition and rebuild and renovation for two schools of approximately 8,000 m² (86,000 sq.ft) each. Another example is in Bordeaux, France, which transformed 530 of its social housing units dating from 1960, rather than demolishing them. Under the motto: “make more and better with less”, the buildings were upgraded and expanded, adding winter gardens, balconies, security systems, and new facilities, to the tower blocs – which earned the architects the Pritzker prize, architecture’s highest honour.

And in Glasgow, in the UK, the Town Hall has set up a City Construction Forum to convene a collaborative network of developers, designers and architects working on projects within the city. The goal is to build a co-operative partnership to expand the possibilities of modularity, disassembly and designing out waste.

Photo by kallerna (CC BY-SA 4.0)

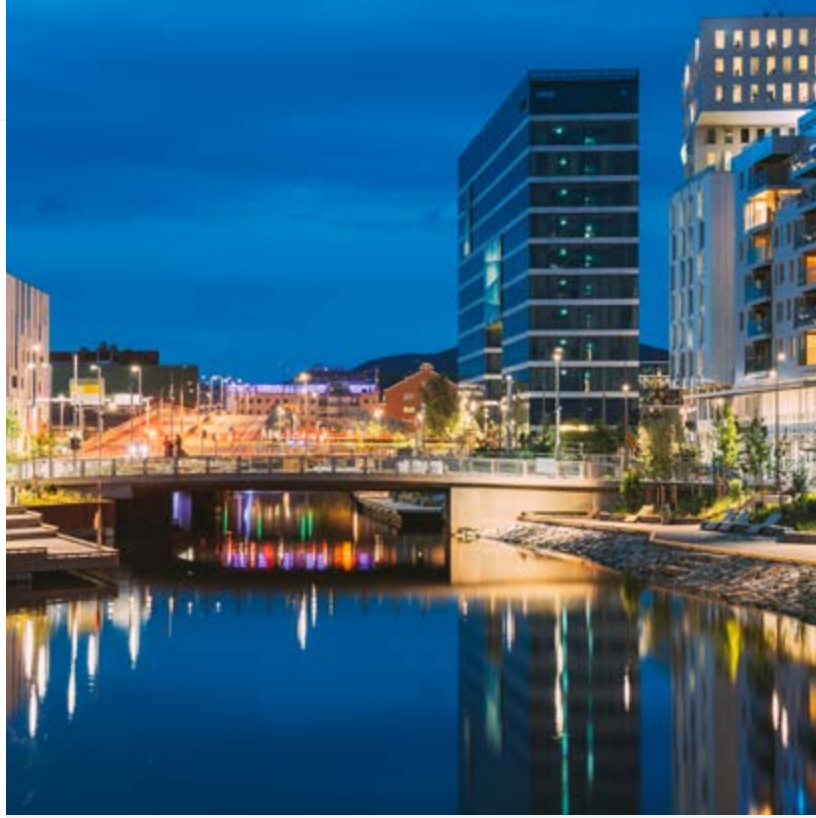
The City of Lahti (Finland) applied the life-cycle carbon and life-cycle cost performance methodology to decide between demolition and rebuild and renovation for two schools.

3. Reduce and Replace materials and structures by design and use lower carbon structures and materials where appropriate.

It is becoming increasingly understood that certain types of building shapes are more carbon efficient than others; both in terms of embodied and operational carbon. When proposals are approved, requiring the use of lighter or more carbon efficient structure should be considered. It also goes without saying that low carbon materials should replace conventional materials where possible.

The city of Helsinki, Finland, has applied wood in construction 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. In the UK, London now sets out a requirement for developments to calculate and reduce whole life cycle (WLC) emissions. This requirement applies to planning applications which are referred to the Mayor, but WLC assessments are encouraged for all major applications.

Finally, Oslo and the surrounding municipalities launched in 2009 the Future Built program to support climate-friendly urban development in the region. In 2019, Oslo celebrated its 10th anniversary with 24 projects being completed and 28 under construction or being planned. The pilot projects are set to reduce greenhouse gas emissions from transport, energy and material consumption by a minimum of 50 percent, and to inspire and change practices in both the private and public sector.



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4. Reuse products and materials, at end of life for additional uses for unused products from sites and for salvaged materials from refurbishments and demolitions.

Developers are increasingly considering a building's End of Life (EOL) potential. The EOL takes into consideration all the carbon emitted at deconstruction. If developers can keep large parts of the building whole to be reused in other projects, carbon emissions can be greatly reduced. So planning proposals should consider what kinds of materials are best recycled at the end of the building's lifespan. For example, brick and mortar facades can be literally transplanted onto another building – a face lift, if you will.

As an example here, Venlo city hall in the Netherlands has been designed and built using 100% design for disassembly principles. And the Netherlands as a whole is currently developing a design for disassembly standards. The City of Amsterdam has published a "Circular Toolbox", with the hope of involving all departments in the city in circular construction. The Toolbox collects articles, examples and reference work on circular themes in construction, such as timber construction, renovation, material passports and revenue models.

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5. Require low carbon products

It goes without saying that planning projects looking to tackle embodied carbon should seek to work with inherently low carbon materials. There are several ways that this can be encouraged, including by:

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

But appropriate materials will differ depending on the type of building and its location. For example, using sustainable materials may be counter-intuitive if huge transport emissions are incurred. For example, Portland, Oregon, has introduced requirements for all concrete in municipal procurement which require product-specific and third-party verified EPD from January 2020. By April 2022, the city will publish maximum acceptable Global Warming Potentials thresholds for concrete on city construction projects (by type of concrete and strength class). The goal is to require all concrete used on City construction projects to meet the GWP thresholds.

In Europe, the Swedish cities of Malmö, Göteborg and Stockholm and the national transport authority Trafikverket have set common environmental requirements for contractors. These specify that 20% of total energy use in machines and transport devices be delivered via renewable energy sources. Likewise, the Norwegian city of Oslo's climate and environmental requirements for construction sites are now mandatory for all construction projects and specify *fossil-free construction* as a minimum criterion.

Portland, Oregon, has introduced requirements for all concrete in municipal procurement and will publish maximum acceptable Global Warming Potentials thresholds for concrete on city construction projects (by type of concrete and strength class).

Municipal deployment - national enforcement

It's important that any policies which restrict buildings' embodied carbon emissions are nationally enforced. If there is discrepancy between locales, this will simply cause developers to avoid areas with harsher restrictions, resulting in so-called 'carbon leakage'.

Solving embodied carbon emissions isn't as simple as promoting one building material over another. As the industry continues to decarbonise, some materials may reduce their embodied carbon percentage, or new materials will come into use.

"This is the new frontier for city-based climate action and has the potential to be a serious game changer for our climate-leading cities. By tackling new construction – which cities are uniquely positioned to do, holding legal and regulatory powers through zoning and land use policies – cities can dramatically reduce a substantial source of carbon emissions. This project points a transformational path forward for our cities, setting a new standard for what's possible".

Johanna Partin
Former Director, Carbon Neutral Cities Alliance

Further reading

CNCA Embodied Carbon City Policy Framework

LINK

Dramatically Reducing Embodied Carbon in Europe's Built Environment

LINK

Factsheets:

what does it mean in practice?

Urban Zoning

Introduction

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Strategies for success

- Optimising efficiency in using or refurbishing existing spaces and facilities.
- Selecting sustainable materials for embodied carbon reduction.
- Introducing regulations for new construction projects.

In practice[1]

Bio-based materials Requirement - e.g. wood, bamboo, straw for new buildings

Award land sales competitions based on life-cycle carbon efficiency of proposed project

Parking Requirement Optimisation

Apartment Size and Space Efficiency Guidelines

Using and Adapting **Existing Buildings**

Upgrade for population increase using existing infrastructure

1 For further information, see the CNCA City Policy Framework for Dramatically Reducing Embodied Carbon.

Urban Zoning Municipal policy

Bio-based materials Requirement - e.g. wood, bamboo, straw for new buildings

Considerations

Bio-based building should not come at the cost of carbon efficient design for deconstruction.

Some cities' zoning authority does not cover materials.

If sustainably sourced bio-based materials are not commercially available, this policy may not be appropriate.

City examples

The Honkasuo zone in Helsinki requires all buildings have a wooden frame and façade. NB: Helsinki is a region abundant in forests.

Six out of nine states in Austria provide grants and loans for low carbon new houses. They award grants per m² for wood-cladding and renewable insulation.

Award land sales competitions based on life-cycle carbon efficiency of proposed project

Considerations

Bidders are asked to calculate and declare the carbon impact of their proposals.

This would be a strong incentive to drive the market.

The winner can receive a financial penalty if targets are not met on completion of the project.

Works best in cities where space is limited.

City examples

Porvoo in Finland sold construction rights by an assessment which rested 30% on life-cycle carbon and 70% on architecture. This achieved the lowest carbon residential building in Finland at the time.

Parking Requirement Optimisation

Considerations

Reduce minimum requirements for parking in cities and enforce maximum requirements.

Parking could also move to a market-based mechanism, saving the city construction costs.

City examples

Helsinki is moving to market-based mechanisms: e.g. Each building determines a number of parking places to build. A plot in the district is reserved for a centralised parking building. If there is demand for parking within 5 years, it is built, otherwise it is rezoned.

Urban Zoning Municipal policy

Apartment Size and Space Efficiency Guidelines

Considerations

Reducing/ waiving minimum space requirements for some apartments can allow reduction of embodied carbon. Minimum room/ storage size requirements would be needed alongside.

In case studies, this policy has been financially attractive to residents and builders, and can balance more onerous policies.

City examples

As of 2016, New York City has no minimum apartment size requirement. Although minimum size requirements remain in place for affordable housing, affordable senior housing and certain districts.

Using and Adapting Existing Buildings

Considerations

Buildings which have limited lifespans should use pre-existing buildings/ parts of buildings.

This avoids landfill/ waste disposal management.

City examples

Battersea Power Station in London has been converted from an old coal power plant into apartments and public facilities – such as theatres.

Upgrade for population increase using existing infrastructure

Considerations

Increasing capacity of existing infrastructure is more capital efficient than new infrastructure. It's more financially viable to achieve when structure requires an upgrade or renovation.

City examples

Oregon (U.S.) are legislating to allow duplex and quadruplex residential units around single shared gardens.

Waste and Circularity

Introduction

Over 80% of a product's environmental impact is determined at the design stage. A lot of this relates to whether products or materials can ever re-enter the value chain, allowing the energy and process emissions 'invested' in them to be 'recycled'. In the ideal circular economy, all waste would be returned to the value chain as inputs. In construction, demolition waste could be used as materials. This would greatly reduce the embodied carbon related emissions of the building sector. With a view towards embodied carbon reduction, developers must consider:

- Increasing the length of a building's lifetime.
- Reuse of materials and components.
- Retaining already expended embodied carbon in stock.

The Ellen Macarthur foundation has published five universal policy goals to enable a circular economy at scale. These are:

1. Stimulate new design norms.
2. Manage resources to preserve value.
3. Get the economics right.
4. Invest in innovation, infrastructure and skills.
5. Collaborate for system change.

Waste and Circularity

Strategies for success

1. Reusing buildings
   - Renovating or reusing an existing building typically reduces the building's embodied carbon by 50-70% compared to new construction[1].
2. Reusing materials
   - Designers should seek out durable and low-maintenance materials.
   - Increasing the use of modular components reduces waste.
3. Designing for deconstruction
   - Element and component checklist.
   - Implementing a scoring system for reuse and recycling potential, accessibility, deconstruction process, connections.
   - Overall deconstruction potential score.
4. Designing for adaptability
   - Designers should optimize structural shapes to use just the amount of material needed.

Data collection will also be key to the circular economy. We can use building information modelling (BIM) to create a database of physical building products, components of materials.

1 Strain, L.: 10 steps to reducing embodied carbon (2017). Available at: https://www.aia.org/articles/70446-ten-steps-to-reducing-embodied-carbon (accessed February 16, 2018). Google Scholar.

In practice[1]

Municipal policy

Helping companies identify **mutually beneficial opportunities to exchange resources**

Outlining practical steps towards **materials reuse and recovery**

Requiring proposals to demolish to be fully justified

Promoting deconstruction rather than demolition

Issuing demolition permits with minimum reuse and recycling requirements

National policy

Denmark

France

Japan

1 For further information, see the CNCA City Policy Framework for Dramatically ReducingEmbodied Carbon: https://drive.google.com/file/d/12oUTOkH3nR8LdZ5VELKWdVHo-Nar1Hag/view?usp=sharing.

Waste and Circularity Municipal policy

Helping companies identify mutually beneficial opportunities to exchange resources

Funded by the City of Cape Town, Western Cape Industrial Symbiosis Programme (WISP) helps companies identify mutually beneficial opportunities to exchange resources.

- The programme has diverted more than 104,900 tonnes of waste from landfill.
- 218 economy-wide jobs have been created.
- For every rand invested, the scheme returned 7 rands in economic benefits.

Example: a marine fishing company's broken fishing nets being repurposed for sports nets and goals in schools and leisure centres.

Outlining practical steps towards materials reuse and recovery

Glasgow has approved Circular Glasgow, which outlines practical steps to work towards supporting economic development, innovation, increasing competitive advantage, resource recovery and reuse, and carbon emission reductions.

Requiring proposals to demolish to be fully justified

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.

Waste and Circularity Municipal policy

Promoting deconstruction rather than demolition

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

Issuing demolition permits with minimum reuse and recycling requirements

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.

Waste and Circularity National policy

Denmark

The Danish Government's Action Plan for Circular Economy constitutes the national plan for the prevention and management of waste for 2020-2032.

In order to reduce the environmental impact from construction and demolition, the government will, among other things:

- Introduce requirements for standardised demolition plans.
- Establish national limit values for problematic substances in recycled concrete and brick.
- Create unambiguous rules and better traceability for construction and demolition waste.

France

Anti-waste Law "Loi AGEC" (2020)

- Phase out single-use plastic packaging by 2040.
- Eliminate waste by encouraging reuse and supporting charities.
- Tackle planned obsolescence - the practice by which manufacturers, e.g. Apple design products which consumers have to replace after a short period.
- Promote better resource management from design stage to materials recovery.
- Give consumers better and more transparent information.
- Increase education.
- Ban the destruction of unsold non-food products - companies will have to reuse, donate or recycle goods rather than landfill or incinerate unsold goods.
- Mandatory repairability index of electronic and electric products - makes consumers aware of repair options.

The law aims to create funds to make space for 70,000 jobs in reuse networks.

Japan

In January 2021, Japan's Ministry of Economy, Trade and Industry and Ministry of the Environment published the Disclosure and Engagement Guidance to Accelerate Sustainable Finance for a Circular Economy to stimulate investment in the circular economy.

Building Regulations

Introduction

Many cities around the world are implementing new building regulations to tackle the embodied carbon question. But attention to embodied carbon in policy making is still relatively new.

The first country to legislate on this issue was the Netherlands, who have placed a cap on whole life emissions in new construction projects since 2013.

Strategies for success

- Investing in national databases and quantification software is critical.
- Measures should be used in tandem with education for businesses and stakeholders.
- Measures should be implemented with a goal to them being ratcheted up.

In practice[1]

Municipal policy

Requirement for a Life Cycle Assessment to mayoral projects

Expedited permitting for low carbon projects

Setting embodied carbon targets on buildings

National policy

Denmark

Finland

France

The Netherlands

Sweden

United Kingdom

1 For further information, see the CNCA City Policy Framework for Dramatically Reducing Embodied Carbon: https://drive.google.com/file/d/120UTOkH3nR8LdZ5VELKWdVHo-Nar1Hag/view?usp=sharing.

Building Regulations Municipal policy

Requirement for a Life Cycle Assessment to mayoral projects

In London, the New London Plan includes the requirement for a Life Cycle Assessment to development proposals referable to the Mayor. Major non-referable development should calculate unregulated emissions and are encouraged to undertake whole life-cycle carbon assessments. The approach to whole life-cycle carbon emissions assessments, including when they should take place, what they should contain and how information should be reported, will be set out in guidance.

Expedited permitting for low carbon projects

In Seattle, the city'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.

Setting embodied carbon targets on buildings

Vancouver plans to transition to zero emissions buildings in all new construction by 2030. To achieve this, the city is setting limits on emissions and energy use in new buildings, and will reduce these limits over time. In addressing the emissions from buildings, Vancouver has set a target on embodied carbon. By 2030, Vancouver aims to ensure 40% less embodied emissions from new buildings and construction projects compared to 2018.

Building Regulations National policy

Denmark

- Denmark sets out phased embodied carbon targets for buildings. Buildings below 1,000 m² will initially only be required to calculate the life cycle assessment (LCA), while buildings over 1,000 m² will also be required to meet embodied CO_2 equivalent (CO_2e) limits, which includes CO_2 and other greenhouse gases converted into equivalent values of global warming potential. The policy will also include more ambitious voluntary targets, building on the test phase of the voluntary sustainability class in 2020, which includes a requirement for LCA calculation.
- The parties to the agreement commit to meeting again in 2023, 2025 and 2027 to tighten embodied CO_2e targets based on the latest knowledge and data[1].

1 https://passivehouseplus.co.uk/news/general/denmark-sets-out-phased-embodied-carbon-targets-for-buildings

Finland

- Finland is aiming at carbon neutrality by 2035, and developing a set of policies, including legislation for low-carbon construction. The new approach includes normative carbon limits for different building types before 2025[1].

1 https://journal-buildingscities.org/articles/10.5334/bc.30/

United Kingdom

- The UK operates a national materials LCA database.
- Free embodied carbon tool - UKGBC.
- A Bill has recently been introduced to cap embodied carbon.

France

- France National Low Carbon Strategy (2015) aims to reduce GHG emissions from the building sector by 50% in 2030 relative to 2015 and by 87% in 2050.
- France has mandated all new public buildings to be built from at least 50% timber of other bio-based materials e.g. hemp/ straw.
- RE2020 becomes mandatory in 2022 for residential buildings, requiring analysis of embodied carbon emissions over the entire life cycle of a building (LCA), and expecting new buildings to meet LCA limits. These limit values will be tightened in 2025, 2028 and 2031. In 2023, RE2020 will expand to cover other types of buildings.
- A French E+C- pilot program allowed cities to increase gross floor area by 15% for life-cycle carbon reductions.

Building Regulations National policy

The Netherlands

- The Netherlands now requires embodied carbon reporting at the building-permit-application stage for new residential and office buildings over 100 m².
- Requires an LCA profile including report on global warming potential, depletion of raw materials and fossil fuels, embodied carbon etc.
- The Netherlands has a strong national EPD database, a standardised method for whole-building LCA, and software tools to support standardisation, aiming to gradually tighten requirements by 2030 at the latest.
- The Dutch Sustainable Public Procurement Policy prefers bidders who adopt circular economy principles.

NB. The Netherlands attempted these policies in 2003 but there was significant resistance from major stakeholders e.g. the real estate sector and contractors who objected to additional cost required for the analysis.

Sweden

- The Swedish Transport Authority requires carbon accounting for new projects over 50M SEK.
- Since beginning of 2022 the new Act of Climate Declarations has been in effect.
  - All new construction of buildings must be accompanied by a report on the climate impact of the building in question and file those with the government to receive final building permit approval.
  - Policy also aimed at increasing building sector's understanding of embodied carbon issues.
  - Maximum values on embodied carbon to be implemented perhaps as soon as 2027.
- The National Board of Housing, Building and Planning provides a climate database, developed in collaboration with the Ministry of Environment in Finland, for calculating the climate impact during construction.

Switzerland

- Switzerland has a certification label 'Minergie-Eco' for new and renovated buildings for which embodied carbon calculations are a requirement.
- All government buildings must be Mingergie-Eco certified.
- The program provides a free Excel tool for calculating embodied carbon in dearly design stages.
- Minergie-Eco is voluntary but some public and private organisations (e.g. the Zurich Cantonal Bank) have made it a requirement for new buildings/ major renovations.
- The City of Zurich has set a 2050 target for life cycle embodied carbon in residential buildings.

Financial Incentives

Introduction

Cities attract the lion's share of global investment each year and many urban neighbourhoods remain attractive stores of values for generations. Because of this, the range of financial incentives and disincentives available to city governments are legion – when it comes to reducing embodied carbon. But each will vary according to the wealth and architectural profile of each city. Eight strategies for success are details below – but not all will be appropriate to all cities. For example, the taxation of unoccupied properties or second homes (a successful policy in many cities) does not so easily apply to developing world cities – or to the poorer neighbourhoods of rich world cities, where tax rebates and tougher regulations on property developers are more likely to have maximum impact.

Strategies for Success

1. Offering tax rebates or reductions for low carbon development projects.
2. Levying super tax on unoccupied properties.
3. Linking municipal land use fees to embodied carbon content (an embodied carbon tax).
4. Awarding grants linked to carbon performance.
5. Including embodied carbon in all climate action plans.
6. Increasing fees for demolition to encourage re-use of materials and buildings.
7. Incentivizing manufacturers to produce low carbon products.
8. Hiking landfill taxes.

In practice[1]

Municipal policy

Offering **tax rebates**

Taxing **unoccupied buildings**

Linking **land use fees** to embodied carbon

Awarding grants

Including embodied carbon in all climate action plans

Increasing **demolition fees**

Incentivizing manufacturers

Raising **taxes on landfill**

1 For further information, see the CNCA City Policy Framework for Dramatically Reducing Embodied Carbon: https://drive.google.com/file/d/120UTOkH3nR8LdZ5VELKWdVHo-Nar1Hag/view?usp=sharing.

Financial Incentives Municipal policy

Offering tax rebates

The City of Milford Property Tax Rebate Program in Connecticut (USA) 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.

Taxing unoccupied buildings

Vancouver's Empty homes tax is 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.

Linking land use fees to embodied carbon

Cities often charge land use fees from projects. These fees could be indexed to project embodied carbon. The charge could also be set up so that very low carbon projects would not pay fees at all or be possibly eligible for cash refunds. Building additional floors onto existing buildings can increase density but this is notoriously difficult to persuade developers to do. A tax break could provide necessary impetus, while increasing taxable building base to offset the discount in the long term.

Financial Incentives Municipal policy

Awarding grants

The Austrian state of Vorarlberg 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.

Including embodied carbon in all climate action plans

Many cities have existing climate action plans, but very few address embodied carbon. 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 go into any depth. The 2019 update to Boston, Massachusetts', climate action plan includes several references to measures the city can take to reduce embodied carbon.

Increasing demolition fees

In 2019, Marin County, San Francisco, increased 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.

Financial Incentives Municipal policy

Incentivizing manufacturers

While there are few examples in practice, 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 energy.

Raising taxes on landfill

In many countries of Eastern Europe, landfill taxes vary between 2,7 EUR to 29,8 EUR per ton ($2,9 to $32]. Whereas, 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. There is evidence that countries that set higher taxes increase the circularity of materials and it is a policy that underpins the basis of the EU's Circular Economy package.

Procurement

Introduction

Cities have huge purchasing power when it comes to the materials used in the construction and maintenance/renovation of their own buildings stock. In many cases, such as in materials for roads, they are by far the largest customers in a sector. Urban areas can also encourage suppliers in the private sector to adopt best practice for non-municipal projects simply by ensuring that their own project standards are consistently and ambitiously applied. At the very least, having embodied carbon requirements for municipal projects forces the construction supply chain to collect data that can then be used to improve products and services for all projects. It also provides an incentive to develop low carbon products – which can sometimes be more expensive at the early stages of development. Enforcement can be incorporated into general contract obligations and requires no specific authority. However, implementing the requirement will be clearly harder if the market has no track record of providing Environmental Product Declarations.

Strategies for success

- Green public procurement for public buildings.
- Requiring all aggregates to be recycled.
- Using low carbon asphalt for roads.
- Requiring the use of certified wood products.
- Requiring 'circularity' in all material purchases.

In practice[1]

Municipal policy

Green public procurement for public buildings

Requiring all aggregates to be recycled

Requiring the use of certified wood products

Requiring 'circularity' in all material purchases

1 For further information, see the CNCA City Policy Framework for Dramatically Reducing Embodied Carbon: https://drive.google.com/file/d/120UTOkH3nR8LdZ5VELKWdVHo-Nar1Hag/view?usp=sharing

Procurement Municipal policy

Green public procurement for public buildings

Step one is to mandate all public buildings to follow a green public procurement scheme that includes embodied carbon, and these are becoming more common. There are templates that can be followed. For example, the EU's Green Public Procurement for Office Buildings, guide includes minimum requirements for recycled content in materials, limits on the amount of construction waste that can be generated by a project and requirements on the waste that should be reused. Similar guides exist in the UK, the US and Finland.

Requiring all aggregates to be recycled

Preventing building aggregates from ending up in landfill avoids a huge amount of environmental damage. Setting a preference for recycled aggregates within a municipal area can, therefore, have a big impact.

The city of Copenhagen, for example, now requires roadbuilders to use building waste as a substitute for base gravel when this is technically or economically sustainable. France, meanwhile, has a national target for a 60% share of reused or recycled building waste materials in road construction for materials bought by national and local authorities.

Requiring the use of certified wood products

Although wood in construction can lower embodied carbon content, there are dangers here – and some certified sustainably forested wood products have been shown to be associated with lower emissions and 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. However, it is extremely important that city authorities are very careful to ensure that any additional wood they produce does not lead to increased harvesting rates – which can have negative carbon impacts.

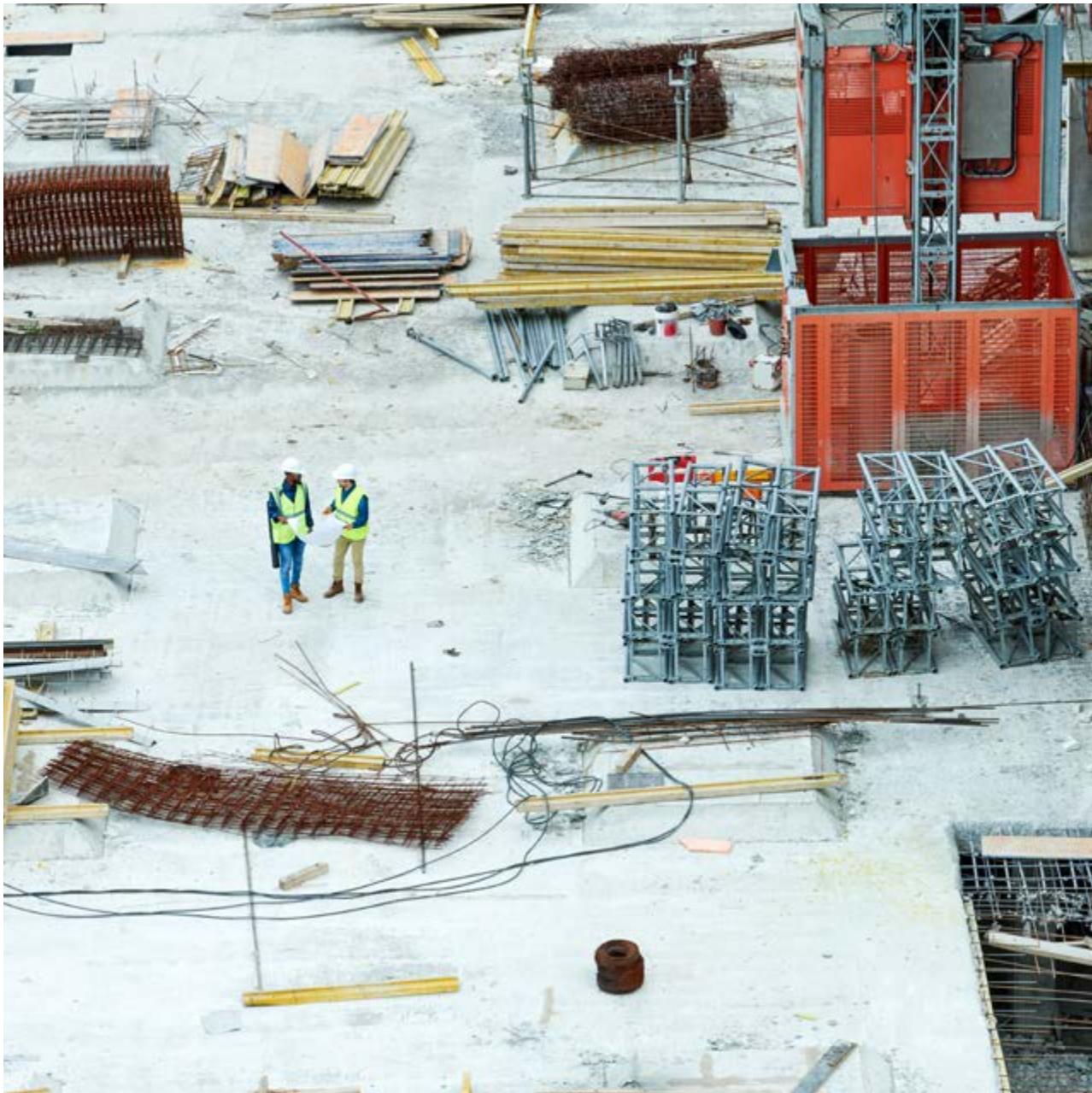
Procurement Municipal policy

Requiring 'circularity' in all material purchases

There is a huge opportunity for cities to design their procurement strategies in order to focus on materials efficiency, circularity, maintainability, repairability and re-use at end of life. Solutions can even be redefined to a service, such as leasing some of the elements – as many cities have done with bike hire schemes or carpooling.

Policy in this area can focus on a single material and need not be prescriptive – such as the City of Rotterdam's 2019 'Circular Concrete Covenant' – signed with the cement sectors and focused on promoting understanding along the value chain as well as just the development of better products and practices.

In Amsterdam, the New Strategy Amsterdam Circular 2020-2025 aims to introduce circular tendering criteria to increase the share of reused and renewable materials and select materials in their projects with the lowest environmental impact.



Communicating the Importance of

Embodied Carbon and Bio-based Materials

in the Built Environment

This document was elaborated by the Carbon Neutral Cities Alliance (CNCA) and Culmer Raphael under the project "Dramatically Reducing Embodied Carbon in Europe's Built Environment", which CNCA launched in 2021 with the support of the Laudes Foundation. The purpose of this document is to serve as a communications material that city staff can resort to when raising the awareness of the importance of addressing embodied carbon and increasing the uptake of bio-based materials among their city-department peers.

About Carbon Neutral Cities Alliance

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.

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