U20
RIYADH 2020
URBAN

Carbon-neutral Buildings and Recycled Materials:

How Cities Want to Solve the Challenge

Circular, Carbon-neutral Economy

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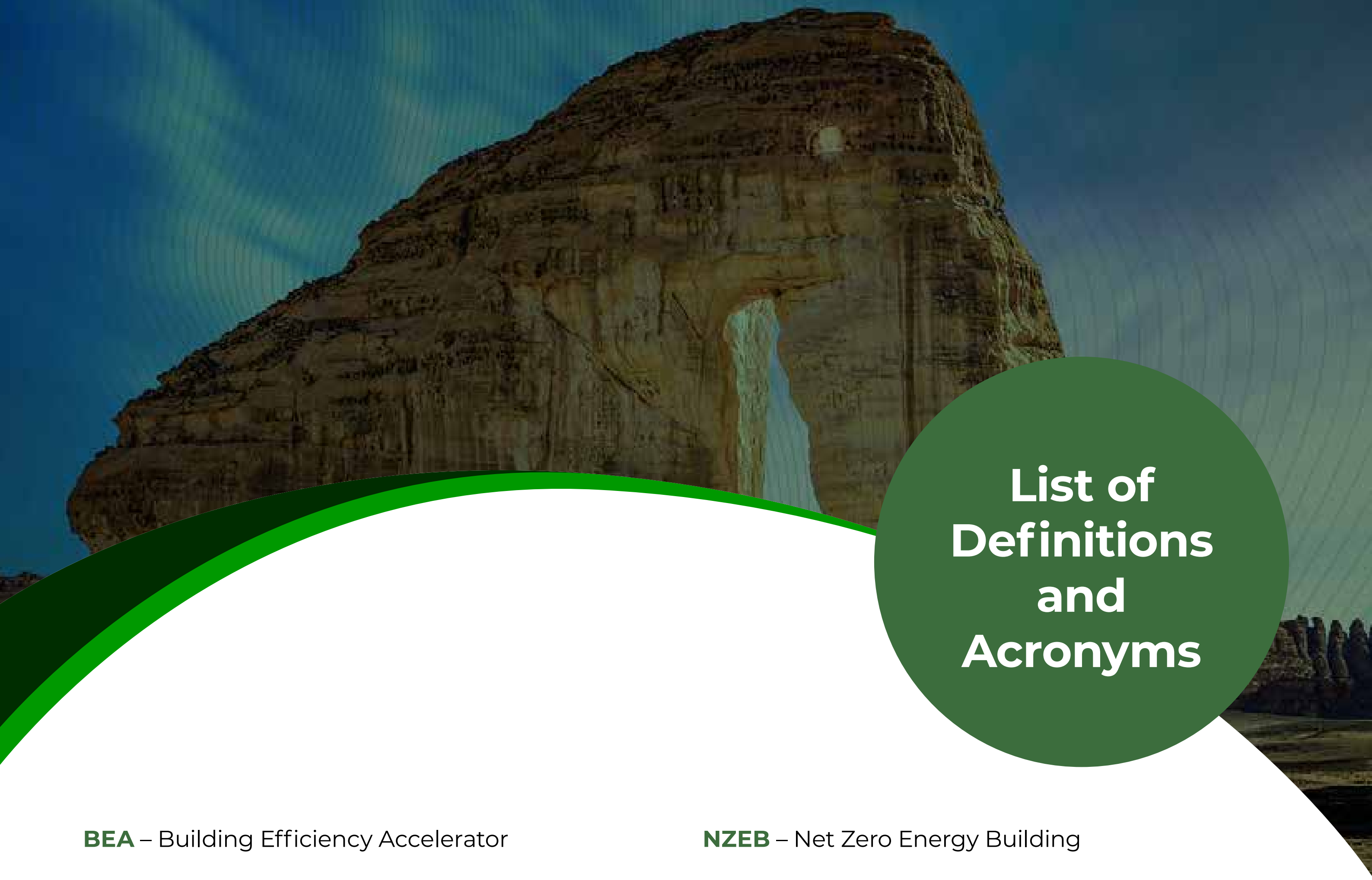


List of Definitions and Acronyms

BEA – Building Efficiency Accelerator

BIM – Building Information Modeling

EPD – Environmental Product Declaration

GHG – Greenhouse Gas

GMO – Genetically Modified Organism

LCA – Life Cycle Analysis

NGO – Non-Governmental Organization

NPV – Net Present Value

NZEB – Net Zero Energy Building

RA – Recycled Aggregate

RAP – Reclaimed Asphalt Pavement

RAS – Reclaimed Asphalt Shingle

RCA – Recycled Concrete Aggregate

SDG – Sustainable Development Goal

WGBC – World Green Building Council

About Urban 20

Urban20 (U20) is a city diplomacy initiative that brings together cities from G20 member states and observer cities from non-G20 states to discuss and form a common position on climate action, social inclusion and integration, and sustainable economic growth. Recommendations are then issued for consideration by the G20. The initiative is convened by C40 Cities, in collaboration with United Cities and Local Governments, under the leadership of a Chair city that rotates annually. The first U20 Mayors Summit took place in Buenos Aires in 2018, and the second took place in Tokyo in 2019. For 2020, Riyadh City is the Chair city and host of the annual Mayors Summit. The first meeting of U20 Sherpas was convened in Riyadh, Saudi Arabia, on the 5th – 6th February during which the foundations were laid for the U20 2020 Mayors Summit in the Saudi capital later this year.

About the Urban 20 Taskforces

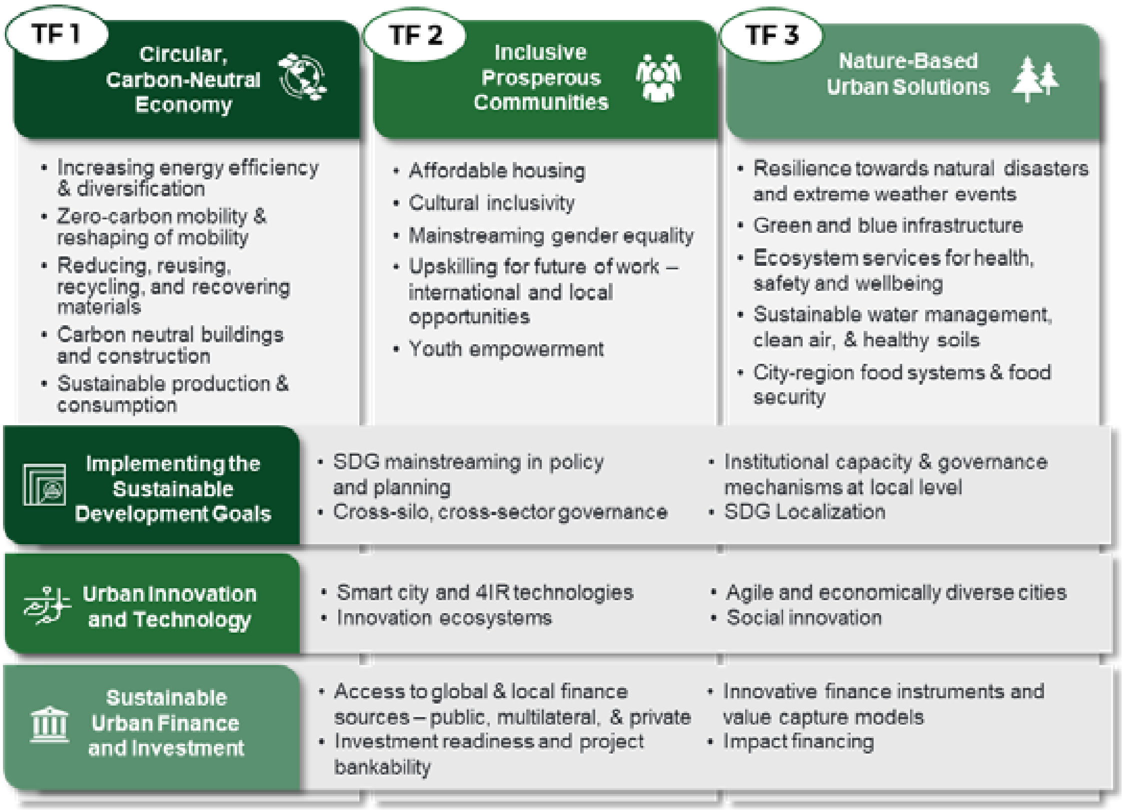
As U20 Chair, Riyadh has introduced taskforces to add additional structure and focus to the U20. These taskforces explore specific priority issues and bring evidence-based solutions to the final Communique.

Each taskforce has commissioned whitepapers led by chair cities, and with input from participating cities and knowledge partners. These whitepapers help us build an evidence-based, credible and achievable set of policy recommendations.

Taskforces activation

The taskforces workstream was an innovative and recent introduction to the three-year-old U20 initiative by the chairmanship of the city of Riyadh this year. Three thematic taskforces, each guided by one of the U20 Riyadh 2020 overarching themes of Circular, Carbon-neutral economy, Inclusive Prosperous Communities, and Nature-based Urban Solutions, were officially launched and activated during the U20 First Sherpa meeting back in February. During the meeting, the U20 priority topics that fell within the three overarching themes and intersecting with the three cross-sectional dimensions of Implementing the Sustainable Development Goals, Urban Innovation and Technology, and Urban Finance and Investment were prioritized and refined through the statements delivered by all attending cities. The top 5 topics were then chosen to be the focus of whitepapers for each taskforce.

The top 5 topics under each of the three taskforces and cross cutting dimensions were then chosen to be the focus of whitepapers for each taskforce:



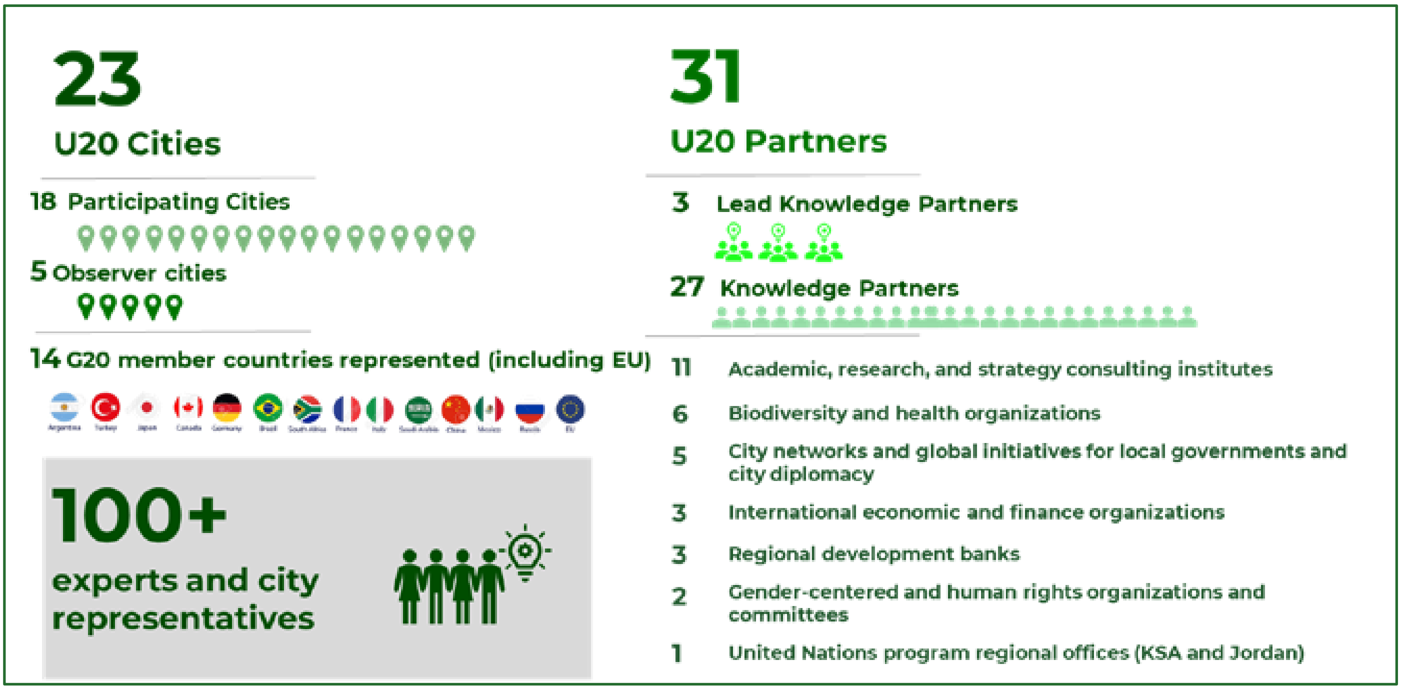
Cities and Partner Engagement

The vast majority of the twenty-three cities who attended the first Sherpa meeting, representing 12 G20 countries, along with the U20 Conveners, agreed to the importance of having taskforces as interactive platforms to produce knowledge-based and evidence-based outcomes that can effectively feed into an actionable U20 Communique. During and following the meeting, several cities demonstrated interest in volunteering in the capacity of chairs and co-chairs, leading and overseeing the activities of each taskforce. The cities of Rome and Tshwane co-chaired Taskforce 1 on Circular, Carbon-neutral Economy, Izmir Taskforce 2 on Inclusive Prosperous Communities, and Durban on Nature-based Urban Solutions. Others expressed interest to participate in the taskforces, some in more than one, both during and after the meeting.

Alongside interested U20 cities, several regional and international organizations proffered to engage in the work of the taskforces, in the capacity of knowledge partners, to share their knowledge and experiences with cities in producing whitepapers. Some of the knowledge partners volunteered to play a leading role as Lead Knowledge Partners, supporting the taskforces' co/chairs in review and guidance

All participants who actively took part of the taskforces were subject matter experts nominated by the cities and knowledge partners and have enriched the taskforces' discussions with their know-how and experiences. In over 3 months, all three taskforces, with great effort and commitment from all their participants, produced a total of 15 evidence-based focused whitepapers, bringing about more than 160 policy recommendations addressing the national governments of the G20 Member States.

The taskforces content development efforts is comprised of 23 U20 cities and 31 U20 knowledge partners. The 100+ experts and city representatives produced 15 whitepapers which widely benefited and informed the development of the first draft of the communique.



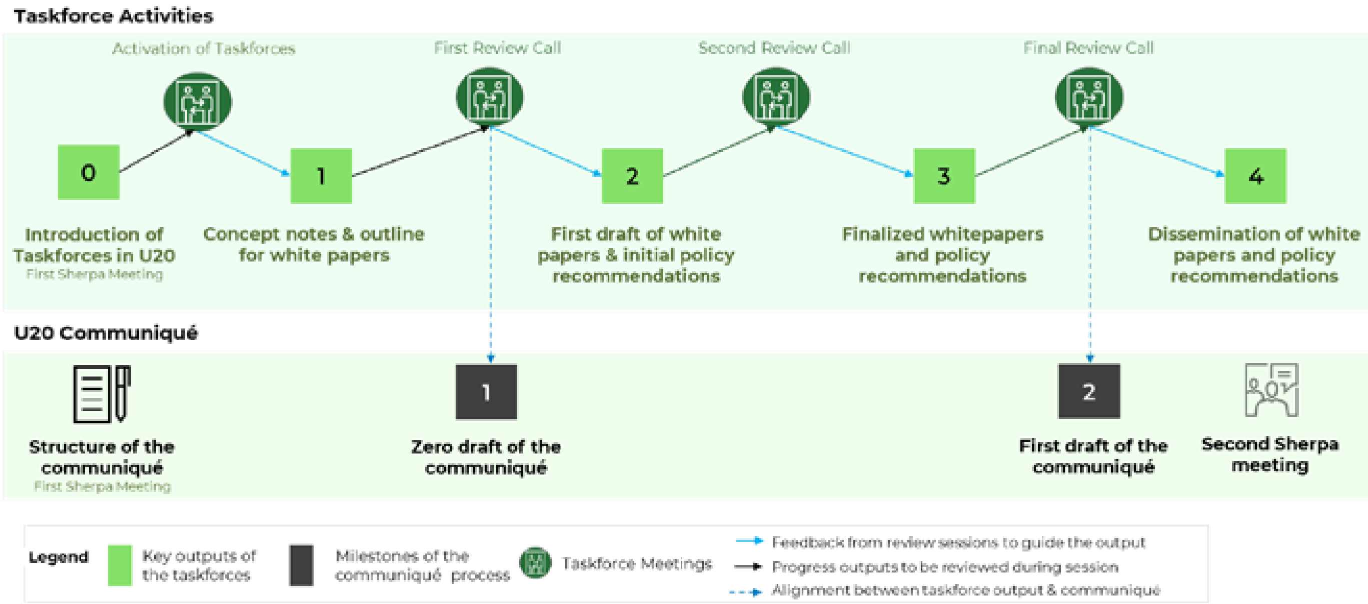
Content Development

Under the leadership and guidance of the co-chair cities, Rome and Tshawne , and the lead knowledge partner, OECD, the work of Task Force 1 kicked off with an orientation for all participants in mid-March.

During the period between March and April, the participants of Taskforce 1 presented more than 20 concept ideas and 12 concept notes and developed initial outlines for the whitepapers focusing on topics of interest. Teaming up into four author groupings, the cities and knowledge partners developed four outlines of whitepapers. Refined and revised outlines were then developed into draft whitepapers that underwent several iterations for development and finalization, ensuring that each paper delivers a set of concrete and targeted policy recommendations that address the different U20 stakeholders.

The four whitepapers under task force 1 (listed below) started with the exploration of the concepts of circular economy across different sectors, with the other three papers zooming into the concepts of circular economy in energy, mobility and buildings sectors :

1. The Post-COVID-19 Circular Economy: Transitioning to Sustainable Consumption and Production in Cities and Regions
2. Efficiency and Diversification: A Framework for Sustainably Transitioning to a Carbon-neutral Economy
3. Reshaping Mobility in Cities for a Carbon-neutral Future
4. Carbon-neutral Buildings and Recycled Materials : How Cities Want to Solve the Challenge



Along the taskforces timeline of activities, three review meetings were held where co/chairs and lead knowledge partners presented and discussed with the U20 Executive Team the progress and findings of the taskforces they represent, leading to the U20 Second Sherpa meeting that took place during the first week of July. Parallel to the taskforces activities, the first draft of the U20 communique was developed by the U20 Executive team incorporating recommendations presented at the third (and final) review meeting.

About the Circular, Carbon-neutral Economy Taskforce

Meeting the global climate targets requires transforming our urban energy systems to be more efficient and based on clean renewable energy sources, while also shifting from a linear material economy to a circular model that reduces, reuses, recovers and recycles scarce and carbon intensive resources

De-carbonization measures in cities such as building retrofitting for energy efficiency, provision of sustainable mobility of people and urban freight based on public transportation and vehicle electrification coupled with the expansion of renewable energy sources could deliver over half of the emission reductions needed to keep global temperature rise below 1.5 degrees Celsius City planning and management approaches can greatly encourage Carbon-neutral lifestyles, through neighborhood walkability and cycling infrastructure, reorganization of food production and distribution for local and organic produce, or support programs for green technology and investment Greenhouse gas emissions from material processes such as infrastructure construction, industry, and household waste need to be taken into account in a full life cycle approach Cities need to reduce the use of carbon intensive and otherwise scarce materials, reuse urban infrastructure and consumer products to extend their lifespan, recover carbon intensive or otherwise scarce material from household waste, industry and physical infrastructure and recycle all materials from plastic to steel, from organics to rare earth materials in a circular economy model that decouples economic growth from carbon emissions.

15 cities

U20 Participating cities

Buenos Aires
Guangzhou
Madrid
Mexico city
Rio de Janeiro
Riyadh
Sao Paulo
Strasbourg
Tokyo

Co-chair cities

Rome
Tshwane

U20 Observer cities

Amman
Dammam
Helsinki
Singapore

13 knowledge partners

Knowledge partners

- Cities Climate Finance Leadership Alliance
- Inter-American Development Bank
- King Abdullah Petroleum Studies and Research Center
- National Institute of Urban Affairs
- Université Nationale Gustave Eiffel
- Center for the Implementation of Public Policies for Equity and Growth
- International Finance Corporation
- World Economic Forum
- University of Pennsylvania, Institute for Urban Research
- World Wildlife Fund
- Coalition of Urban Transitions
- International Association of Public Transport

Lead knowledge partner

OECD

About the Authors & About the Contributors

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Executive Summary

Executive Summary

Policy makers struggle to achieve a balance between carbon neutrality and high recycling rates for three reasons: the level of energy needed to move and adapt construction materials, the variable locations where building activities take place, and the fact that construction waste is not 100 percent inert. However, current research to develop carbon-free technological approaches is advancing, including the accelerated carbonation of recycled concrete aggregates (RCA) and the development of eco-BIM based solutions. However, their impacts are predominantly context dependent.

In line with the G20 Saudi Arabia priority "4Rs" (Reducing, Reusing, Recycling, and Recovering), this whitepaper proposes a series of measures for the national and local level governments to use to overcome some of the hurdles highlighted above.

They are:

- Adapt standards, laws and environmental norms for recycled materials and upgrade the evaluation of environmental indicators;
- Consider recycling materials in new buildings and other public infrastructure as an environmental compensation measure;
- Launch education campaigns for construction company leaders and construction workers about good practices;
- Establish appropriate locations to gather waste from construction and demolition;
- Develop 4R agreements with private companies, boost industrial symbiosis in the construction sector, provide incentives, administrative assistance and public acknowledgement for these programs.

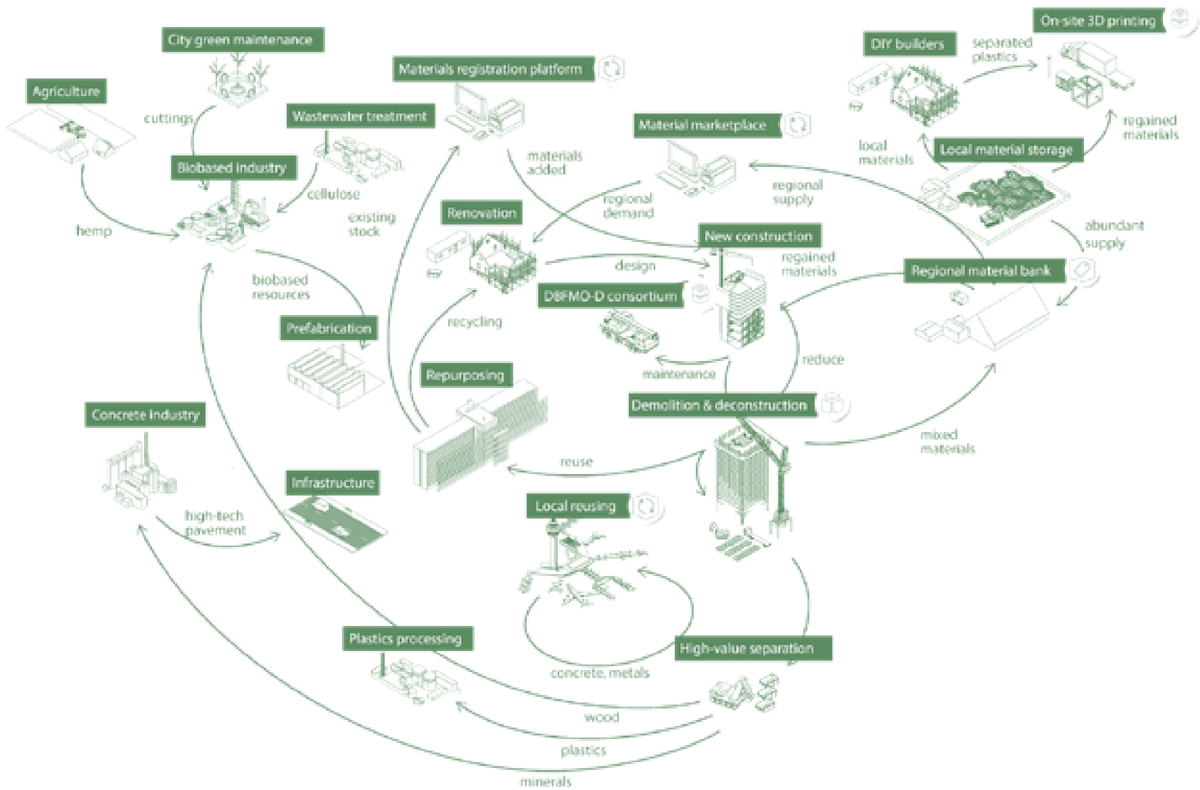
Background

Background

The built environment is one of the most resource-intensive industries (Fig. 1). Globally the construction industry is consuming over three billion tons of raw materials annually and produces an enormous amount of waste. With the world's population expected to rise by over 60 percent in 2050 and the building stock expected to double in size globally, there is a dramatic need to help the industry become more sustainable. Is a target of 39 percent reduction of the carbon emissions from building and construction achievable? According to the World Green Building Council, operational emissions from heat, cooling and lighting could contribute to 28 percent, while 11 percent may come from embodied carbon emissions or upfront carbon associated with materials and construction processes in the whole building lifecycle (WGBC, 2019).

Figure 1.

Material flows in the construction sector



Source: Circle Economy, TNO and Fabric, 2016, quoted by WEF, 2018

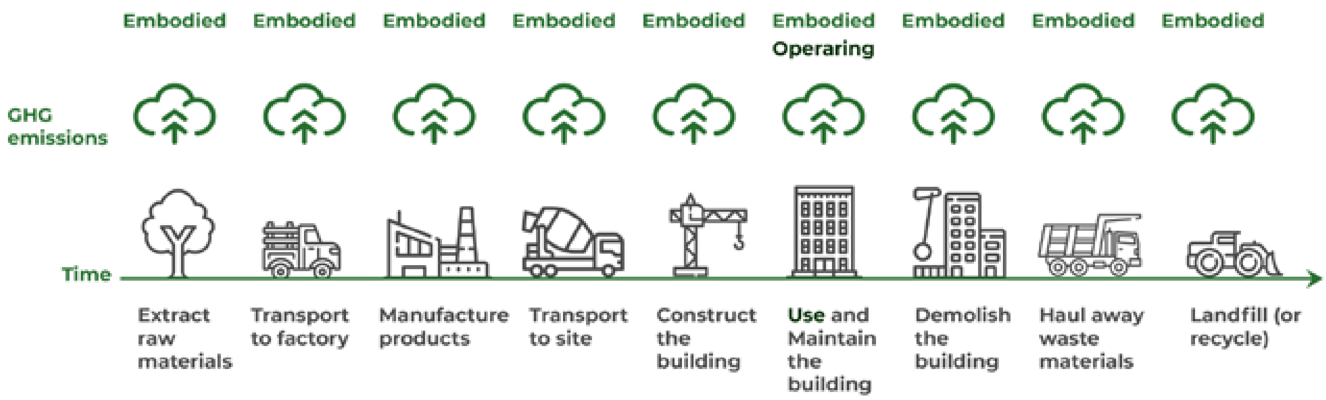
Background

For a long time, it was believed that the construction and demolition waste dumps did not cause damage to the environment, because they thought that the waste generated from these activities was inert. However, today it is known that this is not entirely true. According to (López and Lobo, 2013), demolition waste contains a large number of biodegradable materials such as wood, paper, cardboard and other waste that is capable of biologically degrading which generates greenhouse gases - not to mention the hazardous waste present such as treated wood, paint residues or fluorescent lamps, in addition to the products generated from the decomposition of the waste.

This shows the importance of proper management of construction and demolition waste from the generating source. In their international policy review, (FII, 2017) recalled that "a building is not truly "net-zero" until it has paid back or offset its initial carbon debt (i.e., the embodied GHG emissions associated with materials, manufacturing, and other processes that are upstream of building occupancy) and has considered its future carbon emissions in terms of end-of-life decommissioning". The different sources of embodied carbon as appraised by a Lifecycle analysis (LCA) may be illustrated by Fig 2.

Figure 2.

Lifecycle carbon emissions due to buildings



Source: FII, 2017

Background

Innovation in building technologies and processes is therefore essential to introduce low carbon products in the circular economy construction procedures. For end-of-life buildings (demolition, major refurbishment), there is a need to develop strategies to minimize ultimate waste and to foster potential uses of the generated waste. Transformation to change the current ways of building is required from all sectors, this includes governments, property developers, industries, financial institutions, NGO and the like. It is thus important to have more and more cities, supported by the national governments and local communities, passing bylaws and regulations to deal with construction waste and minimize end-of-life carbon emissions.

Previously U20 has highlighted the issue. The Tokyo U20 Declaration (2019) called to: "enact national regulations and/or planning policy to ensure new buildings operate at net zero carbon by 2030 and all buildings by 2050 with a suite of supporting incentives and programs". The Buenos Aires Communique (2018) advocated for the: "support of city commitments to build resilience and achieve an inclusive and equitable low-carbon transition by advancing zero-carbon buildings, zero-waste, and green and healthy streets in urban areas by lending political support, resources and capacity, specifically for those cities disproportionately affected by the impacts of climate change".

In the Net Zero Carbon Building Declaration signed by pioneering cities in 2018 and by a number of followers, the C40 signatory cities want to: "deliver on the highest ambition of the Paris Agreement and develop the net zero carbon buildings of the future. We pledge to enact regulations and/or planning policy to ensure new buildings operate at net zero carbon by 2030 and all buildings by 2050".

More focused on the implementation of smart technological innovation, the Japanese Government has challenged the "Super City Initiative" since October 2018 and lately the Japanese Diet enacted a bill to create those "Super Cities". Data-linking platforms will collect and organize various kinds of data for a number of urban services, among which energy, water and waste: not a single but several fields of life solution services should be implemented through leading-edge technologies, with a strong participation of the residents (OPRR, 2020).

Education and capacity building will play a critical role for sectors involved, especially government officials and property developers in ensuring a smooth transition to carbon neutral buildings. An extensive stakeholder engagement will be necessary for this transition.

Introduction

Introduction

Carbon-neutrality mostly addresses clean renewable energy sources and energy savings. Circular economy addresses material resources and waste recycling. This whitepaper is an attempt to bridge the two issues. Building on a number of examples and case studies, we want to know under what conditions the increase of circular economy might contribute to carbon neutrality, and what local and national governments could do to achieve tangible results within a reasonable time lapse.

Building is one of the most significant economic sectors in the world and it contributes to a large part to carbon emissions. According to OECD, the building sector has a major impact not only on economic and social activities but also on the natural and built environment. The sector is responsible for about 30 percent of primary energy use in OECD countries. Material flow analyses for some Member countries show that the sector accounts for between one-third and one-half of the commodity flow, when expressed in terms of weight (OECD, Work on Sustainable Buildings, see website). In the European Union, 21.9 percent of the 2017 GHG emissions are due to transport and 11.57 percent to manufacturing industries and construction (CGDD, 2020). In line with the targets set by the Paris Agreement and, in Europe, by the Circular Economy Action Plan for a Cleaner and More Competitive Europe, more and more countries want to reduce the carbon footprint of their civil engineering and construction industry and to achieve carbon neutrality by 2050.

Moreover, under the umbrella of Sustainable Development Goal (SDG) 13 "Take urgent action to combat climate change and its impacts", and SDG 11 "Make cities and human settlements inclusive, safe, resilient and sustainable", cities aim at developing the next generation construction materials and at adapting maintenance techniques. Therefore, an important part of the research conducted by the public and the private sector on concrete, steel, earthwork and pavement issues is devoted to the reduction of the greenhouse gas emissions and to the preservation of existing natural resources.

With a growing urban population, the demand for housing, commercial buildings, office space, schools, hospitals and other buildings increases. Material uses and energy issues in building are highly connected. Ensuring that both new and existing buildings meet high-efficiency energy performance requirements is crucial for cities, especially those already engaged to deliver on international sustainability commitments.

To ensure the construction of buildings that meet the growing social demand for sustainability, guidelines and certifications have been created by international entities, such as the US Green Building Council that provides LEED certifications based on a points system obtained by different categories, among which are they include innovative design, materials and resources, energy and atmosphere among others. Some of the characteristics that are evaluated for materials and resources include the use of recycled, local and rapidly renewable materials. While for energy and atmosphere there is, an energy saving of 12 percent to 48 percent applying the requirements of the ASHRAE Standard 90.1-2007.

Current U20 Trends

This whitepaper attempts to highlight some issues cities are facing when they want to implement a zero-carbon building and construction policy. It is not so easy to find landmarks in such an innovative sector. Rather than attempting to define those policies by a series of theoretical considerations, this paper is building on cities' experiences, summarizing lessons learnt from their practical experience. More cases can be found in international review studies or testimonies, see (FII, 2017), (C40, 2018) and others.

The 2019 U20 Communique urged G20 to collaborate with cities in "Increasing resource efficiency and promoting circularity: Commit to measure and reduce consumption-based emissions substantially; including through new and ambitious global initiatives to reduce emissions from the construction". This paper addresses therefore a top G20 Saudi Arabia priority: how the "4Rs" (Reducing, Reusing, Recycling, and Recovering) will help the construction sector in cities become eventually carbon neutral and pave the way to the goals of the Paris Agreement and The United Nations 2030 Agenda?

In its 2020 Annual Meeting, the WEF expressed that the design of zero carbon buildings and communities was being driven by four major trends: Decarbonization of the electric power grid; Electrification of building space and water heating; Efficiency improvements to reduce energy demand; Digitalization to provide needed flexibility in meeting the needs of building occupants and the energy grid.

We will explore and adapt those Four Good DEEDs and 4Rs to the carbon neutral building issue.

Challenges and Opportunities

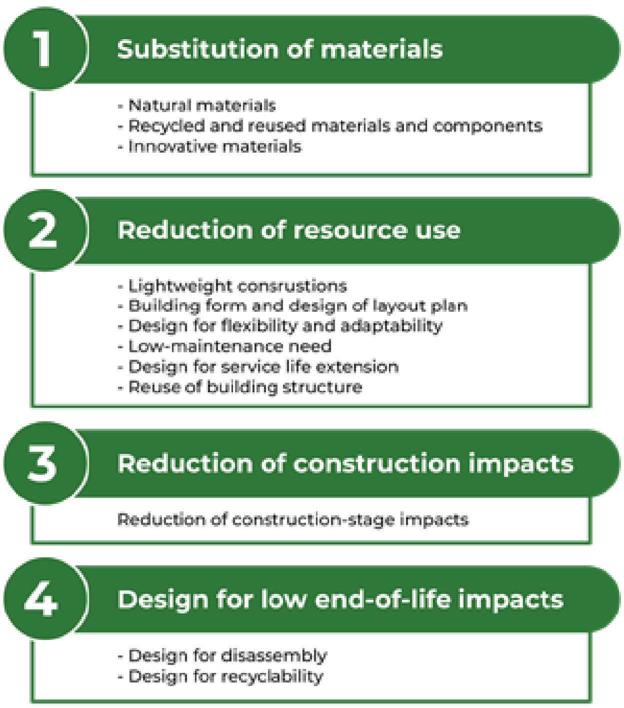
Challenges and Opportunities

Since the construction industry is now running advanced digitalized management tools like BIM - that help companies be more productive - it is very important that the BIM incorporates recycling issues in every step across the project lifecycle. BIM creates a detailed 3D model of a building with information attributes such as location, size and composition of materials used, which passes from architect to contractor to owner and improves the efficiency and economic viability of later decommissioning or retrofitting (Barrie, 2017) and (WEF, 2018b).

Inspired on one hand by the design strategies in Fig. 3 for reducing embodied carbon in construction projects (FII, 2017), and on the other hand by the think steps and stages implemented in a BIM, we have organized the discussion of challenges and opportunities in four tiers: Material manufacturing, Construction, Use and Maintenance, End of Life.

Figure 3.

Design strategies for reducing embodied carbon in construction projects



Source: FII, 2017

Challenges and Opportunities

Material Manufacturing

Material manufacturing includes the process from removal of raw material up until transportation and distribution of building products. Nice promising carbon free technological prospects are ahead of us, but their global impacts are mostly context dependent.

Many research topics for environment friendly materials address reused and recycled materials: complete recycling of concrete, multiple and full recycling asphalt (using additives, e.g. rejuvenators); carbon free materials: accelerated carbonation of recycled concrete aggregates (C02 capture), bio-sourced materials, biomass transformation processes into bitumen-like material (using generally by-products from micro-algae or from agro-industrial residues, avoiding competition with the food production and being careful with the use of GMOs); new construction techniques: better use of on-site materials, soil improvement.

It has been proved at full scale that is it possible to increase the recycling rate of the asphalt materials up to 50 percent and reduce the use of petroleum bitumen (using binder from biomass), without compromising the durability in comparison to conventional techniques (Blanc et al., 2019).

On the other hand, according to some prospective studies (Audo et al., 2015), the technology readiness level of algae transformation process is too low at the moment to reach the market. Depending on the research investment, a 2nd generation of bio-binders could be available in the next 5-10 years.

In the USA, according to (Jones et al., 2020), the most common recyclable material used in road construction are reclaimed asphalt pavement (RAP) and reclaimed asphalt roofing shingles (RAS). "There is growing interest in allowing significantly higher percentages of RAP and RAS in asphalt mixes used on state and local roadways". There are concerns on how these composite binders may influence the performance and durability of asphalt mixes. The researchers found out that, since adding RAP and RAS binder increased the stiffness of blended binders and the RAS binder did not effectively blend with virgin binder, adding a rejuvenating agent may improve the performance of a blended binder.

Example: Mexico City green purchases guidelines (Lineamientos para la adquisición de bienes y servicios de menor impacto ambiental)

The government ministries must do their purchases considering these guidelines. This enforces the environmental sustainability of the government acquisitions. Additionally, service providers must follow these guidelines.

Challenges and Opportunities

Example: Tshwane (South Africa) baseline study on compliance of SANS 10400 XA

This National Building Regulation ensures building efficiency in building developments. The study is meant to check how the city is doing in terms of compliance with the standard and the results will be feed into a process of reviewing the bylaw for low carbon developments in the city. There is need for improvement in enforcing the standard and so there is a lot of training and capacity required for both city officials and developers.

Example: Zero Emission Tokyo

As a global megacity, Tokyo declared it will seek to become a "Zero Emission Tokyo" at the U20 Tokyo Mayors Summit in May 2019 (TMG, 2019). Some of the Tokyo 2030 target actions are linked to construction and material policies: create a mechanism for the effective use of resources utilizing AI/ICT technologies; expand the use of eco materials such as recycled crushed stone, by taking measures to evaluate the quality of the materials; ensure entirely green procurement by promoting green purchase.

Example: Paris Circular Economy Plan

According to the Paris Circular Economy Plan (2017), actions are undertaken in stimulating and coordinating a community of actors in the area of materials reuse, communicating in real time on the successes and failures of experiments, sharing feedback, pooling tools and preparing for scaling up.

Construction

The main interest of recycling of concrete aggregates (RCA) is to save natural aggregates. It then develops as a priority where the cost of natural aggregates becomes over expensive, due to a long-distance transport or an anticipated shortage of local natural aggregates (Recybéton, 2018). However, the recycling of concrete is not in all cases favorable in terms of CO_2, because RCA may be of lower quality (i.e. a higher porosity, which results in a greater water absorption and a slightly impaired mechanical strength) and must be compensated with a little more cement to maintain the required properties when recycling rate increases (Concrete Recycling, 2019).

Life Cycle Assessment (LCA) shows that whenever the recycling technologies using binders from the biomass reduce actually the consumption of non-renewable resources, they may also affect negatively the land use. To increase the use of recycled aggregates (RA) processed at the asphalt plant seems to the most important factor to consider in order to reduce the environmental impact (Blanc et al., 2019). The characteristics of the supply chain are paramount, when transport to get raw materials exceed a certain distance.

Challenges and Opportunities

Example: Tshwane

The City of Tshwane's vision and plan on existing municipal buildings is to ensure that they are retrofitted and refurbished, introducing zero carbon energy generation technology and reducing greenhouse gas emissions. Most of this work has started with the support of Building Efficiency Accelerator (BEA), a programme where the city has committed to ensure building efficiency for municipal owned buildings by embarking on retrofits and introducing renewable energy sources for own use. This will in turn assist the city by reducing emission from city buildings whilst saving on operational costs.

For construction of new buildings, the City of Tshwane is currently reviewing its Green Building Bylaw, which was initial developed do encourage construction of Green and efficient buildings by the city and developers on voluntary basis. The bylaw focuses on sustainability not only on energy in buildings but also on water resource management, waste management in buildings, sustainable transport systems around building developments. The current review seeks to have more ambitious sustainability elements and enforcement of the bylaw to achieve net zero carbon buildings by 2050. The review will also be inclusive of adaptation actions and carbon neutral materials to ensure net zero carbon buildings in the city are achieved.

The City of Tshwane Headquarters (Tshwane House) symbolizes the rebirth of the whole city through innovation, excellence and social cohesion. The city of Tshwane will reap monetary savings and environmental benefits from better management of resources such as water, energy and waste, leading to the reduction of carbon emission. Also, the building brings a healthier work environment with improved air quality, which means cleaner air for employees, a lot of natural light coming into the building, great outdoor views and employees being able to talk to each other more often.

Example: Mexico City

Mexico City has a law that regulates the construction of new buildings to improve the use of renewable resources, like solar heaters or rainwater harvesting. Through this instrument the city officials can verify the project previous the construction reducing the environmental impact.

Many informal masons' workers in Mexico City, doing repairs or little constructions, are often unaware of proper waste management. They need to be included in the educational campaigns, so they are aware of the regulations and of the adverse consequences of bad construction and demolition practices.

Challenges and Opportunities

Example: Paris

The City of Paris (2017) is developing a resilient road guide for resilient paving materials integrating reused materials for construction (cobblestones) and cooling pavements to reduce urban heat islands. The guide also allows the integration of innovative technological solutions (e.g. sensors, nudges and innovative signage) in the design and development of public spaces. The long-term objective is to scale the investment to the entire road network and enable the City's public spaces to become a foundation for resilience building.

Use and Maintenance

Buildings consume a lot of energy while generating a lot of wastage during their life cycle. Building operation includes energy consumption, water use, and environmental waste generation, and/or any repairs and maintenance related activities. According to the Saudi Energy Efficiency Center (SEEC), the building sector's consumption of the total electric energy produced in the Kingdom of Saudi Arabia has exceeded 75 percent. As another figure, the energy used to power, heat and operate buildings accounts for more than 25 percent of the GHG emissions produced by South African cities.

SEEC attributes the increase of the rates in consuming electricity to two main reasons: firstly, the low energy consumption efficiency in the electrical appliances used; and secondly, the lack of thermal insulation in most buildings. The natural and climatic challenges only exacerbate the need and reliance on electricity when operating buildings. Consequently, actions to make buildings more energy efficient have a huge potential to reduce GHG emissions.

According to cities' experience, a number of challenges are linked. The measurement of resource usage and wastage (e.g. water and energy audits) is linked with the existence of a Building Management System. The use of regulated building standards is correlated with the training of staff and of inhabitants. Upon the size of the maintenance budget depends the capability for the sustainable implementation of new promising technologies that will eventually improve the building efficiency and save on operational costs.

Example: Riyadh

The Saudi Energy Efficiency Program (SEEP) prepared by SEEC has implemented a series of secondary programs to rationalize electricity consumption in buildings. One of SEEP's primary initiatives is the acceleration in the implementation of the Royal Order, issued in 2009, to oblige all new buildings to apply the thermal insulation, given that applying thermal insulation reduces energy consumption in buildings by a rate ranging between 30+40 percent. This initiative is carried out in parallel to updating 15 standard specifications for 10 new thermal insulation materials, updating the standard specification for air conditioners and other household appliances.

(Continue)

Challenges and Opportunities

Example: Riyadh

In collaboration with Saudi Basic Industries Corporation (SABIC) and adhering to the standards set by SEEC, the city of Riyadh demonstrated that building to superior levels of performance is possible despite the challenging environments (Alshenaifi, 2015). A demonstration house was developed in 2015 as part of the "Home of Innovation", a regional growth program initiated by SABIC in a commercial business park in Riyadh. The 800-square-meter demonstration house was the first single-family home in the Middle East to earn a Platinum certification under LEED (USGBC). Some of the sustainable outputs achieved from this project were: a reduction of a 38 percent in overall energy use compared to villas of similar size; the maintenance of healthy air quality using a robust fresh-air ventilation and filtration system; the reduction of energy demand from the local power grid, with a 28-kW solar array on the roof, as well as a pair of solar thermal collectors, with an ultimate design to achieve a net-zero energy balance; a 40 percent reduction in potable water usage with technologies and appliances facilitating the reclamation of grey/rainwater.

Example: Mexico City

Mexico City has a program dedicated to certifying buildings sustainability from a global environmental perspective, criteria include water, energy, and waste management under the umbrella of the "Solar City" program. The aim is to promote the incorporation of systems and technology that enables the efficient use of energy and the reduction of pollutant emissions. As of now, the program is voluntary, but participants are given fiscal benefits such as discounts on the property tax and payroll tax cuts.

Example: Net Zero Energy Building in Nordic countries

The analysis of the NZEB (Net Zero Energy Building) energy performance requirements and reference apartment buildings in four Nordic countries (Estonia, Norway, Finland and Sweden) showed that Estonia may be most energy-efficient (Kurnitski, 2019). A combination of favorable circumstances and political leadership explain this good performance : (a) a quick process to prepare the requirements and the adaptation path (two rounds of enforcement): the first energy efficiency requirements were established in 2008, the requirements became stricter in 2013, targeting 2019 for public buildings and 2020 for residential buildings; (b) a favorable economic environment for decision makers, that allow higher construction costs be offset by lower lifecycle cost; (c) the definition of a common metric based on the net present value (NPV) of a 30-year life cycle: the costs are composed of the construction costs, the 30-years maintenance and operation costs, the discount rate and the foreseen time series of energy prices; the energy consumption has also to take into account the conversion factor of the primary energy content of the energy delivered into the building.

Challenges and Opportunities

Example: Amsterdam

EDGE Olympic, in the Amsterdam's financial district, completed 2018, is the first building in the Netherlands to achieve WELL Platinum certification for enhancing health and wellbeing for its positive impacts on human health and wellbeing. The office building is based on an old, existing building that had exceeded its lifespan. Since the basic structure which was still usable, the building was redeveloped instead of being demolished. As a result, no new raw materials were needed. Those materials that could no longer be used were given a new purpose within the new version of the building: the old natural stones, for instance, now serve as flooring on the ground floor. Thought has also been given to the lifespan of the building: the top two floors have a wooden construction that can be disassembled relatively easily for future reuse (this part of the building is cradle-to-cradle certified).

Example: Life Cycle Analysis

Example of LCA enforcements are reported by (FII, 2017). The United Kingdom's dominant voluntary green building rating system, Building Research Establishment Environmental Assessment Method (BREEAM), has long had an LCA component. Whole-building LCA is required for new German federal construction as part of the mandatory Assessment System for Sustainable Building (Bewertungssystem Nachhaltiges Bauen or BNB) which is a green building certification system. The German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen, DGNB) issued a voluntary green building certification system with a LCA performance strategy that is similar to BNB.

Both systems include pre-determined standard embodied carbon performance benchmarks and award points based on relative performance against these benchmarks. Those programs are supported by a strong technical infrastructure such as a free national LCA/EPD database and a free national whole-building LCA software tool. Under the program, me called Positive Energy and Carbon Reduction (Energie Positive et Réduction Carbone), the French government offers various incentives to motivate builders and developers to meet energy and carbon-performance benchmarks. For instance, new buildings can apply for additional rights to construction density above zoning limits if they show proof of meeting energy and life-cycle carbon (including embodied) performance targets. They may also receive financial assistance to support LCA studies or receive the national label.

Challenges and Opportunities

End of Life

Approximately two-thirds of the CO_2 emissions of the cement industry are due to the decarbonation of limestone during the manufacture of cement. The reversal of this process occurs naturally and is referred to as the “carbonation of concrete”. During the service phase, between 10 and 15 percent of the CO_2 emitted by decarbonation of the limestone can be reabsorbed, and 25 percent more during the demolition (CEN, 2019). The slow yearly natural carbonation process can be accelerated and transform recycling aggregates into carbon sinks (dos Reis et al., submitted).

The energy consumed and the environmental waste produced due to building demolition and disposal of materials are the topics of intense R&D projects. An important research program me going on presently is thus to store CO_2 in the Recycled Concrete Aggregates, while improving the quality of this aggregate by plugging the porosity, and ultimately reducing the impact of the CO_2 in the concrete contained in structures (Torrenti, 2019).

Example: Paris

The flow of final waste from building materials represents a volume of 3.5 million tons per year in Paris, of which the vast majority is excavated earth. In the Île-de-France region, waste from construction and public works sites represents an estimated potential resource of 30 million tons, of which around 14 million is from the building sector (67 percent for deconstruction activities, 28 percent for renewal and 5 percent for new build). Material recovery (recycling) of construction and public works waste is currently estimated to be only 26 percent in Île-de-France.

Paris’ road regulations require that materials from road works are taken to a City of Paris materials recycling center to be reworked or recycled. Out of the 15,000 tons of granite laid every year, 50 percent is sourced from recycled granite (Circular Economy Plan, 2017). In order to ensure optimal use of recycled materials, the City of Paris sells part of its stocks.

Plaine Commune (in the Ile-de-France region) has conducted a metabolism study and mapped out land resources that could be mobilized to store and recover materials from construction projects in its territory. This requires: collection points located near deconstruction sites or drop-off points near recycling centers / distributors; processing or dismantling centers for recycling channels; grouping or storage sites for each recycling channel or building site.

Within the framework of the Grenelle Environment Roundtable and the Energy Transition Law for Green Growth, several commitments directly concerning construction and public works waste have been made in France: Obligation to perform a waste diagnosis for sites larger than 1000 m^2; material recovery of 70 percent of construction and demolition waste by 2020 (European Framework Directive of 19 November 2008).

Challenges and Opportunities

Example: Mexico City

Mexico City currently generates approximately 14,000 t/day of construction and demolition waste of which only 206 tons per day are recycled. For this reason, the city developed the Zero Waste Plan: For a circular economy (Mexico City Government, 2018), which established a pathway to treat this kind of waste. The plan considers the installation of six of construction and demolition waste recycling plants and promotes the installation of a central collection center in coordination with the plants. Currently, there is an open call direct to the private sector to install these plants. It is expected to increase the recycled waste to 6,000 tons in 2024. These plants will be able to process and stabilize construction and demolition waste so it can be reintegrated in the construction of new buildings and public infrastructure. According to the Zero Waste vision, the waste can be processed and stabilized so that it can be reintegrated into new value chains, opening the opportunity for the creation of new companies that can provide the service of collecting and recycling materials, creating a more circular city in terms for the building sector.

Currently, the Ministry of Environment of Mexico City is working on an environmental standard that regulates the amount and type of recycled materials (from construction and demolition waste) to be used in new constructions and public infrastructure. The private sector as well as academia is actively involved in the elaboration of the standard.

Recommendations

Recommendations

According to the Paris Circular Economy Plan (2017), there is much to be gained by "designing new business models that offer more incentives for all actors in the value chain, either by increasing the potential revenue for actors (higher sales prices), or by reducing costs (for example by developing tools to analyze projects in terms of the overall cost or to optimize costs through materials savings or pooling). Furthermore, many obstacles related to regulations (mandatory approval of building materials and processes), materials (difficulty of storing materials produced by construction in dense areas) and funding (cost overruns related to changes in practices in particular) stand in the way".

In order to create and to scale up new innovation opportunities in cities, we call for the implementation of new construction techniques, such as a better use of on-site materials, for a dramatic improvement of countries' procurement schemes, for the development of standards open to innovation, for building codes that include a regulation of building materials, for the renewal of the urban innovation institutional framework, such as risk sharing instruments to enable innovative businesses, and to adaptation pathways that help overcome the temporal mismatch between short term decisions and long term goals.

Material Manufacturing

- National and/or international standardization bodies should adopt standards for a broad series of recycled materials and, working together with the private sector, propose guidelines to advance the wide adoption of smart technologies.
- National governments should modify existing laws and environmental norms to mandate increased use of recycled materials in new building and public infrastructure construction.
- Regulatory bodies and NGOs should consider the use of recycled materials as an environmental compensation measure.

Construction

- National governments should work with local governments to establish a pipeline of climate-safe, bankable projects to anchor compact, connected, clean urban development.
- Public and private owners (clients) should transform traditional prescriptive approaches into performance-based ones.
- Private sector, acting together with cities, should launch large education campaigns for construction company leaders and construction workers about good practices regarding the application of the '4Rs' (Reducing, Reusing, Recycling, Recovering) to construction and demolition waste.
- National governments should upgrade the evaluation of environmental indicators and collect elements from universities, NGOs and consultancy.
- National governments and cities may offer incentives and public acknowledgment to those incorporating recycled construction materials and post-use materials in buildings.

Recommendations

Use and Maintenance

- Local governments should provide administrative assistance to companies interested in installing facilities to recycle construction and demolition waste.
- National governments should undertake agreements with the private sector or industry, to increase the use of recycled materials.
- Local governments can contribute to the creation of new jobs by promoting the training in the installation and use of technologies that contribute to sustainability.

End of Life

- Land planners and municipalities should establish appropriate locations to store, process and reuse construction and demolitions waste.
- National governments should encourage industrial symbiosis in the construction sector to reduce the generation of waste.

Conclusion

Conclusion

The selection of examples in this whitepaper illustrates how cities want to solve the challenge of carbon neutrality and implement SDG 13 "Take urgent action to combat climate change and its impacts" and SDG 11 "Make cities and human settlements inclusive, safe, resilient and sustainable".

The national and local governments together with the private sector should combine their efforts: governments, to prepare and enforce technical standards, environmental norms and safety regulations, to support research ; cities, to enable logistics, to find recycling places, to provide administrative assistance, to foster implementation projects, to assess the risks and give the starting signal ; both, to take a synergic political leadership, to fund and manage economic incentives ; private Companies to invest in R&D, to adapt to new procurement schemes and to share the risks.

Carbon-neutral building is mainly a matter of trade-off between immediate construction costs and delayed maintenance and exploitation costs. Such a trade-off is always based on an economic forecast that consider e.g. the energy supply costs and the technological readiness of carbon free construction materials. A recent research report issued by NCHRP for traffic and transportation studies explains that "there are all kinds of reasons why actual numbers would be different from forecasted predictions. COVID-19 is a perfect example. The events that can cause errors in our forecasts are often bigger or different than we might anticipate a priori. It is important to look back at past inaccuracies when considering future uncertainties." (Erhardt & al., 2020).

Today's challenge is how to continue to forecast through COVID-19. A renewed approach of uncertainty in the construction sector, based on a critical review of the accuracy of past forecasts, would be worth developing. Actually, a better understanding of the uncertainties and bias would provide more confidence and lead to better choices.

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Appendices

Appendices

Reducing the carbon footprint in concrete construction through accelerated natural recarbonation

The reduction of the greenhouse gas emissions and the preservation of existing natural resources is among the most important issues the concrete industry is facing. This goal involves carbon neutral constructions throughout their life cycle: construction, operation, demolition, reuse and recycling. To achieve this goal a coordinated action by all those involved in construction is paramount. This is summarized by "the 5C Approach" of the European Cement Association (Cembureau): Clinker, Cement, Concrete, Construction and built environment, (re)Carbonation. Each of those items has to contribute to the objective.

The cement industry is committed to reducing emissions. Measures are underway: e.g. use raw materials, burn fuels that emit less CO_2, carry out research and development on Capture and Use of CO_2 (CCU).

The FastCarb project in France (accelerated carbonation of recycled concrete aggregate - fastcarb.fr) is the outcome of three major observations.

- First, the production of cement is a major source of global CO_2 emissions, accounting for 5-7 percent of the total. Approximately two-thirds of these emissions are due to the decarbonation of limestone during the manufacture of Portland cement. The reversal of this process occurs naturally and is referred to as the "carbonation of concrete." However, natural carbonation is a very slow process.
- Second, a large amount of the recycled concrete that comes from the deconstruction of buildings and structures is available, while natural resources must be conserved. Even if recycled concrete aggregates (RCA) can be used as such in concrete by adjusting the mixtures, RCA have higher porosity. This impacts negatively the performance of recycled material, resulting in greater water absorption and impaired mechanical performance. As a result, in order to use high recycling rates without losing the engineering properties required for concrete, it is necessary to increase the mixture's binder content.
- Nevertheless, recycled aggregates contain specific chemical elements (portlandite and hydrated silicates) that are likely to be carbonated more rapidly than the structural concrete. The goal is thus to store CO_2 in the RCA, to improve the quality of the aggregate by plugging the porosity, and ultimately to reduce the CO_2 footprint of concrete construction.

(Continue)

Appendices

Reducing the carbon footprint in concrete construction through accelerated natural recarbonation

In FastCarb laboratories are modeling the factors affecting the carbonation process as a natural and as an accelerated phenomenon. In laboratory conditions, one can store between 10 to 50 kg of CO_2 per ton of RCA. Accelerated carbonation is performed under industrial conditions in order to test the feasibility of the methods and the first results show around 30 kg of CO_2 capture per ton of RCA.

The industrial experiments try nowadays to optimize the process and treat larger quantities of recycled aggregates we. Environmental evaluations of the process must be performed (Life Cycle Analysis – LCA) and outlooks for the cost of CO_2. must be contemplated in order to ensure a real economic and environmental attractivity.

Using concrete to build buildings or civil work infrastructure in cities in 2050 will only be possible if all those involved in construction, and not just cement manufacturers, work together to achieve carbon neutrality. Alone, the acceleration of natural concrete recarbonation is not enough to solve the problem, but it represents a significant and promising contribution at global scale.

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