GLOBE

Global consensus on sustainability in the Built Environment

DECARBONISING GLOBAL CONSTRUCTION

- by the Joint Committee on the Globe Consensus

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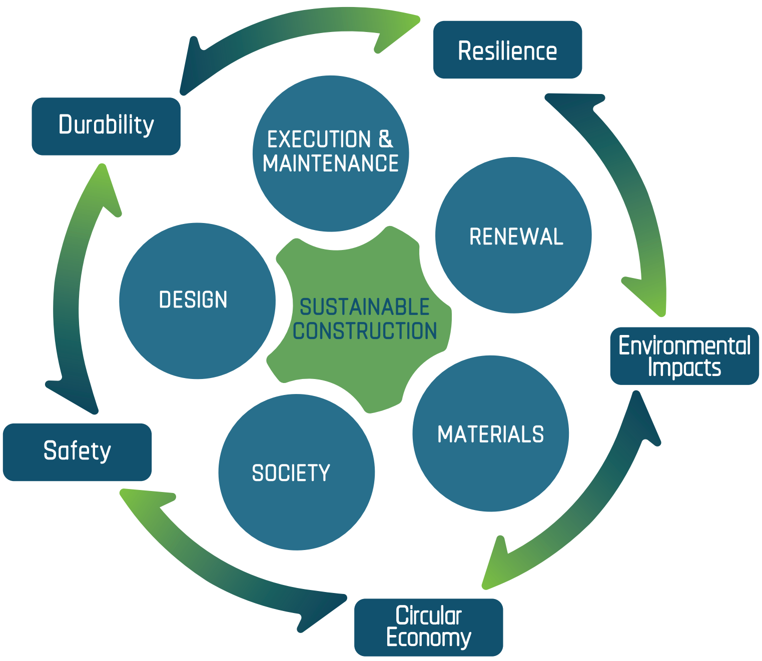
1. THE JOINT COMMITTEE ON THE GLOBE CONSENSUS

The Joint Committee on the GLOBE Consensus (GLOBE) (http://globe-consensus.com/) is a committee dedicated to reducing Green House Gas emissions from construction. GLOBE has been brought to life by the Liaison Committee of the six associations CIB – the International Council for Research and Innovation in Building and Construction (https://cibworld.org/), ECCS – the European Convention for Constructional Steel Work (https://www.steelconstruct.com/), *fib* – the International Federation for Structural Concrete (https://www.fib-international.org/), IABSE – the International Association for Bridge and Structural Engineering (https://www.iabse.org/), IASS - International Association for Shell and Spatial Structures (https://iass-structures.org/) and RILEM – the International Union of Laboratories and Experts in Construction Materials (https://www.rilem.net/), Systems and Structures. These six associations are responsible for the development of technical guidelines, standards, innovation, research and education in construction at international level for more than 50 years. They represent more than 150 nation states and more than 5000 experts. Hence, the backbone of GLOBE is the knowledge represented by the associations with respect to the entire value chain of construction. This includes the expertise of materials engineers, structural engineers, safety and resilience engineers, consulting engineers, contractors, owners and operators, experts in standards and codes, as well as policymakers.



GLOBE at a glance;

- is an independent committee, free from industrial and political interest,
- strives to provide an integral perspective on greenhouse gas emissions from structural design over construction materials to safety and resilience assessment, construction, maintenance and dismantlement or reuse of structures in the built environment.
- advises on sustainable solutions at a global scale with due consideration of regional differences in needs and capacities,
- represents professionals with the local contextual knowledge that ensures the development of technical solutions and their optimal implementation in the cultural, geographical and socio-economic context they aim to serve.

2. EXECUTIVE SUMMARY

The global contribution of the embodied Green House Gas (GHG) emissions from construction amounts to a total of around 20% of global GHG emissions. Three-quarters of these emissions originate from concrete and steel alone, simply because these materials are in large volumes in construction. In the quest to mitigate climate change and the associated disastrous consequences, immediate actions must be taken to reduce emissions from construction.

Decarbonisation of construction goes far beyond renewable energy transition and carbon capture technologies. To reach the goals of the Paris agreement the importance of the role of embodied GHGs in construction must be recognised and the different parts of the sector must work together to drastically reduce these.

Within the next 30-50 years, the global demand for development of housing and new infrastructure poses a substantial challenge to the global community. This development will be driven especially by the Global South, where the majority of new construction will occur. Immediate action is needed to implement the best knowledge and technology we already have at our disposal today. A paradigm shift in construction to adopt new best practices must be implemented at global scale.

Using less materials, and using materials with less embodied carbon, must be appreciated as fundamental means for the decarbonisation of the construction sector. Key obstacles are lack of organization in the construction sector and inadequate regulatory frameworks, codes and standards.

All actions identified can be implemented quickly with the support of the GLOBE expert network, in collaboration with other relevant actors and organisations in all regions of the world. The GLOBE network can contribute with knowledge bridging structural design and material sciences. Moreover, GLOBE, through its global network of associations and experts engaged in codes and standards writing, has the regulatory impact and local outreach required to help facilitate the global implementation of the needed changes, respecting regional and cultural contexts.

3. THE IMPACT OF CONSTRUCTION ON GHG EMISSIONS.

The Intergovernmental Panel on Climate Change states that in order to meet the Paris Agreement, emissions must be halved by 2030 and reach zero by 2050. With current commitments, this target may not be reached, but the more rapidly actions are taken, the less dramatic the damage and the lower the need for expensive and not yet mature carbon capture technologies.

The operational and embodied GHG emissions of buildings presently account for almost 40% of global energy-related GHG emissions. In the past decades, substantial progress has been made in improving the energy efficiency of buildings and in the decarbonisation of electricity provision. In contrast, little progress has been made on reducing embodied GHG in construction, and the rapidly increasing global urbanisation will require more and more resources. The only solution is a radical change in the manner by which materials and construction technologies are applied in the built environment.

THE CHALLENGE - GLOBAL DEMANDS FOR CONSTRUCTION

The demand for construction will increase in both the Global South and the Global North. In the Global South, the major need is associated with population growth and fast-developing urbanisation. In the Global North, renovation of existing buildings and maintenance of infrastructure (including to improve resilience) are drivers for future construction demands.

The global embodied GHG emissions from construction amounts to nearly 20% of global emissions caused by human activities. The challenge is to implement solutions that can fulfil the growing need for construction but with less materials and significantly lower carbon footprint. We can already do a lot; presently available technologies have a potential to reduce embodied emissions from construction by close to 50%.

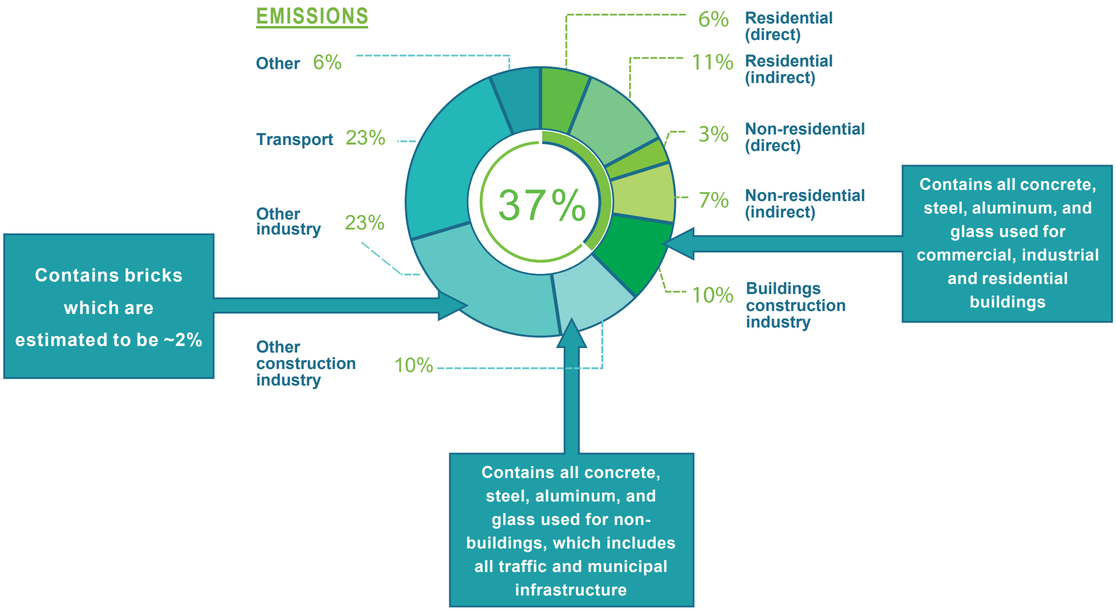


Figure 1 Mapping of sources and amounts of carbon emissions in construction. Adapted from https://globalabc.org/resources/publications/2021-global-status-report-buildings-and-construction.

Quantifying the embodied GHG from construction is complicated. Figure 1 shows the breakdown of emissions from the UN Global ABC, based on IEA figures. The 10% indicated for *"Building Construction Industry"* "relates only to Buildings, this includes only about 50% of the cement and steel used in construction. The rest is included in the *"Other Construction Industry"* section, which concerns infrastructure construction. In addition, the GHG emissions from bricks (estimated at by GLOBE at around 2% overall) come in the *"Other Industry Section"*. This indicates that overall 22% of global GHG emissions relate to construction with a further 28% coming from the operational energy of buildings (heating, cooling, lighting, etc.).

Two materials, cement used in concrete and mortar, and steel, account for about 75% of the construction-related emissions, and for these materials a large share of emission come from the process chemistry rather than energy. These materials cannot be significantly replaced for structural applications, since they are the only materials that can meet the global demand for the foreseeable future. Of course, other materials have a role to play depending on the local context, and such possibilities should be identified and used appropriately.

BIO-BASED MATERIALS

Timber, wood or bio-based materials have gained significant attention as possible substitutes for concrete and steel. They can contribute to reduce GHG emissions where they are provided by sustainable sources, and their increased use should be pursued in this light.

However, as the demand for construction materials on a global scale far exceeds the supply of bio-based materials, their increased utilization can only make a limited contribution to the required reductions.

It takes considerable time to produce timber for construction. Moreover, cultivation of bio-based materials, in general, requires considerable space. For these reasons, the supply of biobased materials is limited.

Furthermore, there are many construction needs which cannot be fulfilled by bio-based materials due to their strength, stiffness and durability characteristics: tunnels and long span bridges for example.

4. REGIONAL SHIFT IN CONSTRUCTION AND DEVELOPMENT

Since 1990, there has been a dramatic shift in construction, from the Global North to the Global South and this trend is expected to continue for the next decades. It is forecast that up to 5 billion m^2 of floor area per year[1] will be needed up to 2050, of which 85% in the Global South. This is an increase to 150% of the amount which is already built. Thus, the global community must focus on how to meet these demands for construction sustainably.

[1] https://www.unep.org/news-and-stories/press-release/buildings-and-construction-sector-grows-time-running-out-cut-energy

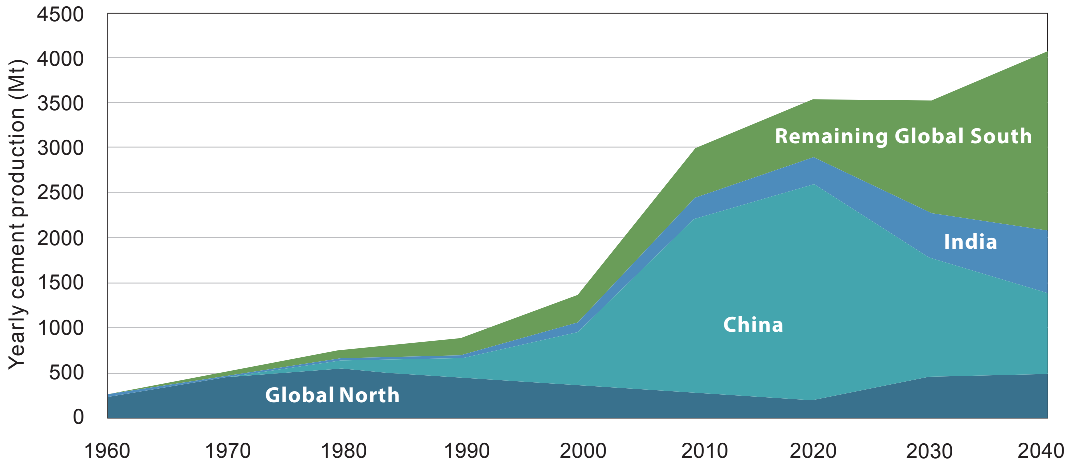


Figure 2 Past and projected cement production in the Global South and Global North. (Global North = North America + Europe + Russia + Japan; Remaining Global South = Africa + Latin America + Africa + Rest of Asia excluding China and India)

Compared to energy, the percentage of construction related emissions is much higher in developing countries. For example, the global average cement related emissions comprise around 7-8% of total global emissions from human activities. In the USA it accounts for only 1.3%, not least due to high levels of energy consumption. In contrast, due to much lower levels of energy consumption in many developing countries, it amounts to 20% or more.

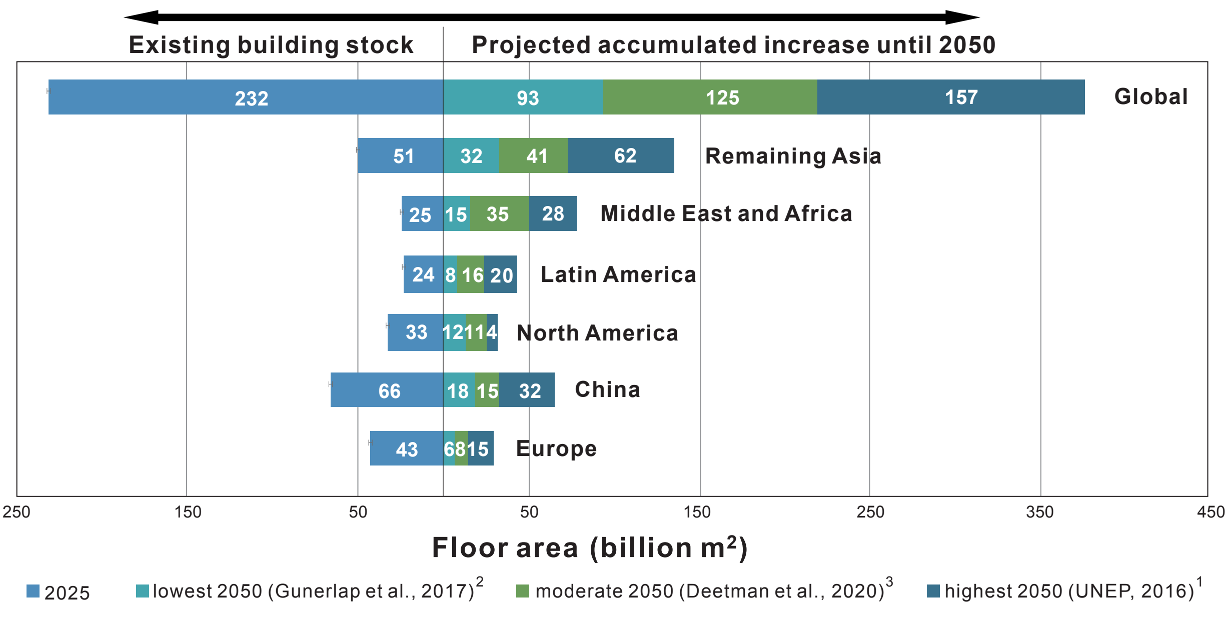


Figure 3 Projected population developments around the globe and corresponding developments in floor area[1,2,3], in Billion m^2

The projections for cement consumption (Figure 2) may, with good approximation, be used as a general indicator of construction activity up to 2050. Based on this, it can be seen that countries of the global North will contribute with only about 10% to global construction

[2]Güneralp, B., Zhou, Y., Ürge-Vorsatz, D., Gupta, M., Yu, S., Patel, P.L., Fragkias, M., Li, X. and Seto, K.C., 2017. Global scenarios of urban density and its impacts on building energy use through 2050. *Proceedings of the National Academy of Sciences*, *114(34)*, pp.8945-8950.

[3]Deetman, S., Marinova, S., van der Voet, E., van Vuuren, D.P., Edelenbosch, O. and Heijungs, R., 2020. Modelling global material stocks and flows for residential and service sector buildings towards 2050. *Journal of Cleaner Production*, *245*, p.118658.

throughout the next decades. China's demand for new construction is expected to decline, but will still account for about one third of global construction activities in 2050.

Substantial growth in India and other developing countries is expected. In India, it is estimated that less than half of the housing and infrastructure needed in 2050 already exists today. In African, 80% of the urban structures that will be needed in 2050 are yet to be built, as the population is forecast to increase from 1 billion in 2010 to 2 billion by 2050. Even though already existing knowledge and technologies could lead to a reduction of emissions by 70-80%, the framework for the implementation is challenging since, in most African countries, around 80-90% of construction takes place in the informal sector.

Therefore, a clear focus on reducing the embodied emissions associated with future construction in developing countries is especially relevant, particularly since most of these countries have a tremendous capacity to maintain their low emissions from energy by applying renewable technologies, whereas the population growth, particularly in South and South-East Asia, and Africa (Figure 4) inevitably increases demands for more construction.

It is evident that a paradigm shift is needed to develop feasible solutions which can be implemented everywhere and by everyone in the world, across the diversity of geographical contexts, cultures and livelihoods.

5. HOW CAN GHG EMISSIONS FROM CONSTRUCTION BE REDUCED?

Investors, owners and operators, planners, developers, architects and designers all influence the decision-making process in construction and, thus, have an indisputable responsibility for ensuring sustainability in construction. Within the regulatory constraints of standards and codes serving to ensure safety, decisions are dominated by demands for minimising cost and time of construction. Consequently, the common practices in the construction sector do not meet the global need for reducing GHG emissions.

The need for systemic changes of the construction industry

An increasing number of actors in the construction industry are looking to lower the GHG emissions, but are challenged by the fact that the sector involves a large number of uncoordinated competing businesses and has small profit margins. There is a strong need to establish an organisational framework, including the different stakeholders, to ensure that adequate incentives to act sustainably are identified and implemented throughout the construction value chain. To progress, all the stakeholders must work together from the outset along a protracted unidirectional chain from the investor to the planner to the architect to the engineer to the constructor and to the supplier. Global benchmarking of construction practices, materials and their carbon intensities, can contribute to the quest of identifying opportunities to reduce GHG emissions.

Therefore, a framework for collaboration must be facilitated in which investors, planners, architects, structural engineers and materials suppliers can apply their specific expertise to identify the overall best solution in synergy. However, such a reorganization will take significant amounts of time and efforts, why other measures for decarbonising construction must be devised and implemented in parallel.

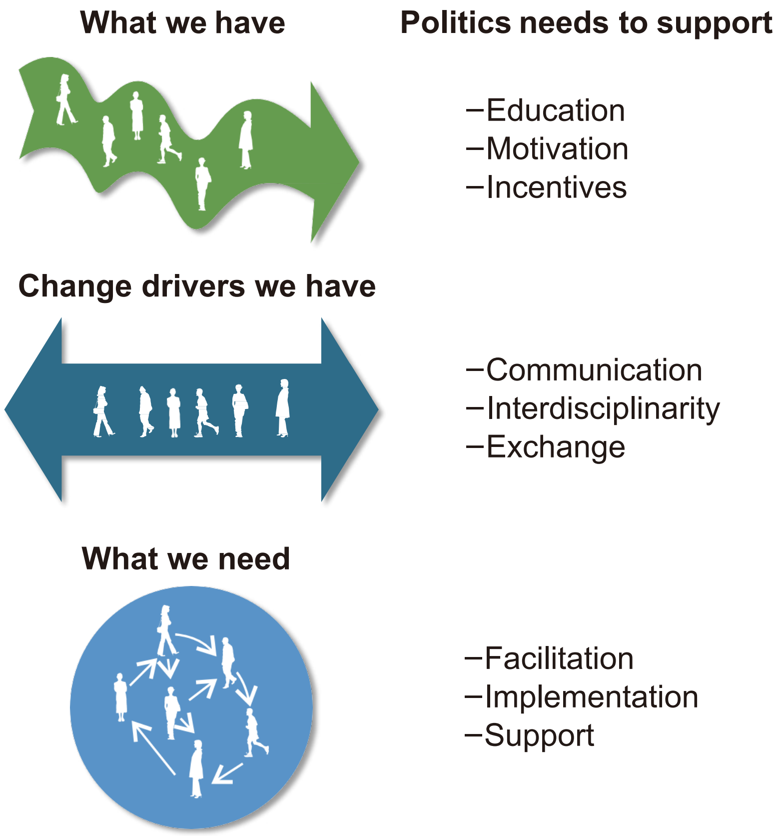


Figure 4 Instruments, drivers and needs for transition of best practices.

Reducing carbon in design and construction

The reduction of GHG emissions from construction may be achieved in principle by two means:

- Reduction of the overall use of construction materials
- Use of materials with lower GHG emissions

These must be considered jointly when minimising the GHG footprint of construction, of course subject to fulfilment of requirements to safety, robustness and resilience. This concerns both new construction and retrofitting of existing structures.

Reduction of the overall use of materials in construction

Considering the specific demands for construction in the future, it is useful to focus on the potentials for[4]:

- Smart renovation and upgrading of existing buildings and infrastructure through the use of good practice.
- Advanced methods of safety verification.
- Improved and innovative materials.
- Minimising the use of materials through optimisation of structural concepts and forms.
- Reducing the need for new construction through enhanced durability of structures and active means for safety and integrity management.
- Implementation of circular economy as a means of minimizing materials and energy consumption through reuse of structural components and recycling of construction materials.

CAN WE BUILD LESS?

The fastest way to minimise emissions is to avoid building anything new altogether. However, particularly in regions with increasing population this would imperil the achievement of most SDGs related to livelihood, health, welfare and social stability.

In many socio-geographical contexts, reuse and responsible retrofitting of the existing building stock may be utilized as means for significant reductions of GHG emissions, while at the same time also boosting job opportunities.

Where buildings cannot be reused due to technical or functional obsolescence, material use can still be minimised through the utilization of more efficient structural concepts. In more general terms, this means: identifying and applying architectural solutions that consider the flow of forces as well as the specific characteristics of different materials. Architectural visions leading to wasteful use of materials should of course be avoided.

Examples: Despite the additional column required, bisecting the span of a beam can potentially reduce the carbon footprint by 30 to 45%. A single 50-storey skyscraper requires twice as much material for vertical elements as two 25-storey buildings.

[4]More information on technological measures may be found here GLOBE - Global Consensus on Sustainability in the Built Environment (rilem.net).

Reducing the GHG intensity of materials

Reducing material use has the potential to reduce GHG emissions by up to 50% through smarter use of existing standards and codes and their improvement. At the same time, there is an urgent need for construction materials with lower GHG emissions. It is of utmost importance that as soon as possible, a new generation of materials comes into the market, for use in mainstream construction projects.

While designers, contractors, developers and planners have to focus on using less material, materials researchers, scientists, manufacturers and R&D investors need to drive the development of materials with low GHG intensity. Due to research and development timescales, reducing the GHG intensity of materials may take longer.

Many apparently innovative materials and technologies are not scalable to accommodate for global needs and challenges. Therefore, investing in the research of GHG reduction for common construction materials has to be put on the very top of the agendas of governments and investors immediately, in order to help deliver viable materials with minimised GHG emissions by 2050.

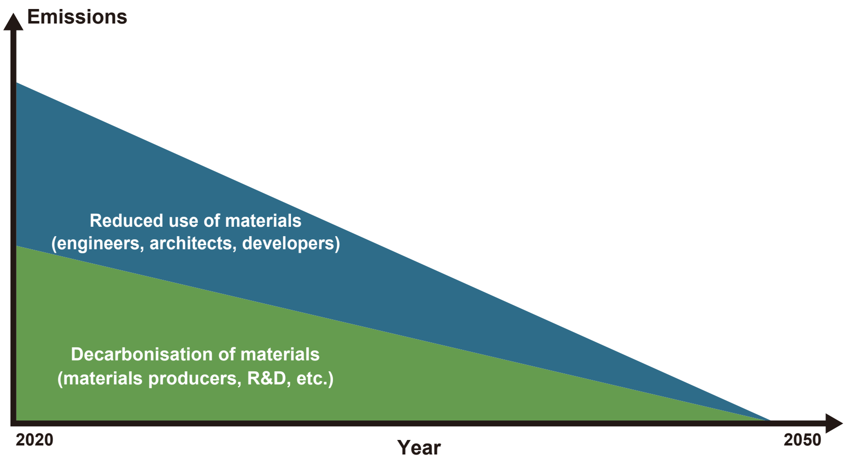


Figure 5 Blue-print for decarbonising construction.

INSIGNIFICANT SOLUTIONS AND GREENWASHING ARE DISTORTING THE PICTURE

Unfortunately, many construction products and solutions presently being marketed as “low-carbon” or “green” are no better with respect to GHG emissions than traditional solutions. Most “low-carbon” concretes and steels presently available at scale rely on substituting cement with waste by-products (typically from coal-powered industries) and substituting virgin steel with scrap steel. In the case of steel, the steel demand is three times as high as the steel that exists in scrap form. All scrap steel is, however, already utilized and it is internationally traded. Buying steel with high scrap content may lower a project’s embodied carbon but has no effect in terms of global carbon reductions, as the scrap inevitably will be used.

In the case of concrete there is a wide range of cement replacements and wide variation in extent of utilization. In some locations, typically where use of low carbon materials and sustainable design is more mature, available cement replacements are at present fully utilized. In these locations, increased use of these materials in one project simply displaces them from another project, with no change in total embodied carbon. In other locations there remains a historical and cultural reluctance to use anything other than Portland clinker cement, despite cement replacements being available and even stockpiled. In these locations, changing public procurement specifications, to require cement replacements, would lead to meaningful carbon reductions.

The so-far advertised and pursued solutions, even if they are all implemented, are not enough. More research and innovation in scalable solutions is needed. Accelerated R&D funding is needed.

6. REGULATIONS, CODES AND STANDARDS AS CHANGE DRIVERS

The development of current codes and standards has been driven by the industries engaged in construction under the overview of public authorities and experts. Due to incremental developments these documents are strongly influenced by traditions. The form and content of standards and codes as we know them today were shaped in times when climate change induced by GHG emissions was not an issue of concern. The leading objective of codes for the design and assessment of structures is to ensure that the risk of materials or structural failure is acceptably low from a socio-economic perspective. In order to help structural engineers to achieve safety in structural design efficiently, the codes are generally written in a manner aimed to be as straightforward to use as possible, however this often leaves little space for engineers to innovate.

Due to an industrial focus on “ease of use”, reduction of liabilities of designers, and maintenance of markets by material producers, standards and codes have not included notable provisions for reducing the GHG emissions from structures. Even the most recent revisions of the structural Eurocodes have negligible considerations of sustainability and provide very little space for optimising the structural design with sustainability objectives.

The huge number of existing, over-complex codes and standards turns out to be an obstacle for rapid implementation of sustainable concepts today. In fact, the standards and codes, in many ways, limit the possibilities of architects and design engineers for optimising the GHG emission performances of structures. The regulatory framework around the design of structures needs re-engineering and massive reduction to a point, where the fundamental principles are regulated but there are sufficient degrees of freedom to allow for the rapid implementation of yet unknown future technologies. This requires more performance-based approaches, which can be regularly calibrated against data-driven global and national benchmarks.

To achieve standards that prioritise GHG emission reduction and safety, there should be global and concerted efforts to develop novel standards centred on sustainability and mitigation of global climate change. Such efforts inevitably require involvement of stakeholders from all regions in the world, particularly those in the global South that, until now, have not played a major role in the development of codes and regulations for construction. National unilateralism should be avoided in developing sustainability-focused standards and design codes, since the reduction of GHG emissions can only be achieved with the global implications in mind - and through a global effort.

POTENTIAL FOR REDESIGNING STRUCTURAL CODES AND STANDARDS

Building regulations have significant potential as instruments to influence the global construction industry. Considering the price and time pressures in the industry, regulations are probably the only real promising instrument presently available. Smart use of design codes, guided by use of benchmarks, and the eventual redesign and updating of codes and standards have a very large potential for improving the GHG emission performances of structures - by up to 50%.

A major benefit of the redesign of standards and codes would be through the introduction of more advanced verification methods, optimised safety formats and allowance for evidence-based and active measures for integrity management.

Limits to allowable emissions of GHG (e.g. per square meter and year) as well as benchmarks and guidelines for design and construction, are needed. These should be adapted to local geographical and societal contexts.

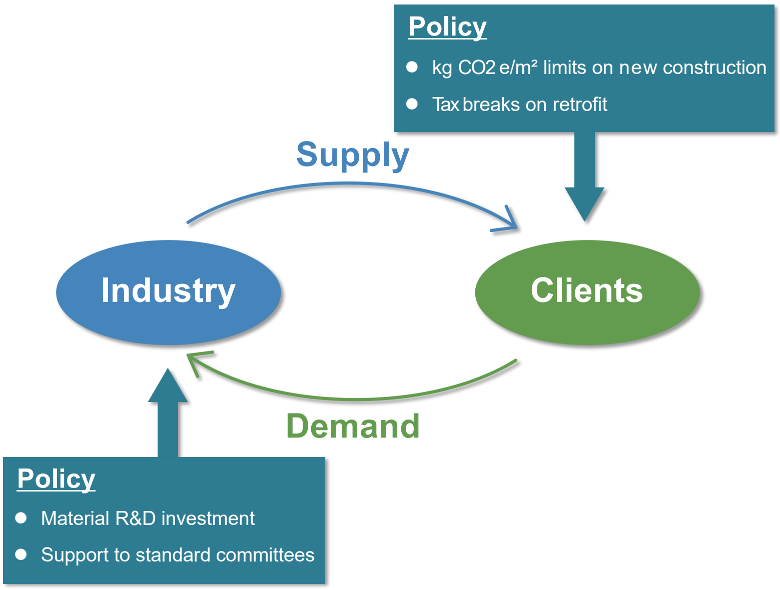


Figure 6 How policies may contribute to decarbonising construction.

7. PRIORITIES FOR IMMEDIATE ACTIONS

Considering the urgency of the situation short, mid and long terms initiatives must be started and promoted in parallel. The following addresses efforts of relevance on the short to mid-term.

Frameworks for collaboration

It is crucial that the industry is aligned and can work together on fair terms, with respect to changes of best practices needed from their side. This necessitates that public and private tenders for material production, consulting and contracting can be negotiated on a common basis at the global level. It is advised that actions are taken to adapt already existing frameworks or to develop a new framework as soon as possible. This should be achievable within two to three years.

Standards and codes

Standards and codes must be redesigned to position emissions of GHG on equal terms as requirements for safety and serviceability. This requires a major internationally coordinated effort - for example, within the ISO framework. To achieve this may require three to five years if pushed hard and supported adequately. After establishing generally applicable principles within the ISO framework, it is necessary to adapt the general principles to national and regional frameworks, which may take another five to ten years. In addition, it is possible already now within the existing framework of codes and standards to produce special application documents which provide advice for designers on how to reduce GHG emissions most efficiently, but this needs to be aligned with the aforementioned international activities and must not create obstacles for new code concepts. Such special application documents should include requirements for maximum allowable GHG emissions for different categories of buildings and structures and provide guidance and benchmarks to help designers moving towards improved best practices.

Materials development

Lower carbon types of concrete and steel must be developed, and standards for their production and quality assurance established rapidly. This will require careful consideration of the raw materials available in the different parts of the world, supply chains, the expected future demands for construction, available regulatory frameworks and not least the cultural and socio-economic contexts to ensure that technological developments are relevant where they are intended to be implemented.

Communication within the industry

A platform for the exchange of knowledge and technologies of relevance for reducing GHG emissions from construction is urgently needed. Such a platform should facilitate and promote mutual knowledge transfer regionally and globally, between:

- different stakeholders of the construction sector,
- different parties within regional and global supply and value chains,
- different countries, regions, and cultural areas, and
- different generations and hierarchies,

Such a platform could be initiated immediately and could be implemented within two to three years.

Communication beyond the industry

The awareness and understanding of the urgency and the relevant means for reducing the GHG emissions from construction must be raised in public administrations, at the political decision-making level, as well as in the broad public to avoid the misdirection of efforts and investments into insignificant or greenwashing solutions. This includes awareness of regional characteristics to avoid that solutions are only applicable in the parts of the world where they are developed. The platform above could be extended to provide an adequate basis for providing relevant knowledge and support to the broad public, political decision-makers and investors to ensure that solutions with scientific evidence prevail over purely marketing-driven solutions

Education

Efforts must be made immediately to reach out to the next generation of engineers and stakeholders of the construction industry. Activities supporting this include educational activities on sustainable construction at all levels, from schools, through universities, vocational training, and continuing professional education. It is advised to initiate a globally coordinated activity of joint engagement of students and industry. This helps to ensure that focus is directed on the need for sustainable construction, that students are provided a platform for contributing, no matter where they live, and that the industry is connected with students with innovative ideas as well as academia, to support their own developments. Given adequate resources, the preparation of such an activity could be completed within one or two years.

8. ON THE ROLE OF THE JOINT COMMITTEE ON THE GLOBE CONSENSUS

The multidisciplinary GLOBE expert network provides the knowledge required to make optimal decisions with respect to combinations of possible choices regarding materials and design, how such choices affect GHG emissions, safety and economy and how standards and codes may be adapted to account for this. GLOBE members are influential in the process of establishing standards, and in the development of underlying concepts, especially for structural design and safety, which are crucial for both mitigation and adaptation of the built environment.

All the immediate actions identified can be planned, organised and conducted with the help of the GLOBE expert network. In pursuit of this, the Globe network is seeking to collaborate with even more global and or regional organizations in the search for low-carbon sustainable solutions which are adequate to a complex global reality.

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A policy note within the framework of GLOBE,
The Global Consensus on Sustainability in the Built Environment

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