# LOW-CARBON CONCRETE AND CONSTRUCTION:
## A REVIEW OF GREEN PUBLIC PROCUREMENT PROGRAMMES

MISSION POSSIBLE PARTNERSHIP

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For the Concrete Action for Climate Initiative

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**Cover: André Boto, GCCA Concrete in Life 2021 Photography Competition**

# FOREWORD

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As the need to stem climate change gains in urgency virtually by the day, new environmentally sensitive practices and policies targeted at limiting the global average temperature increase to 1.5°C above pre-industrial levels are essential. This is particularly relevant in the manufacturing of cement – the key ingredient in concrete. The world is in the midst of an infrastructure and building boom as new economies emerge and developed economies expand. Concrete, already the most consumed human-made resource on Earth, will continue to be the material at the centre of these construction activities. The problem is, cement manufacturing is responsible for approximately 7% of global carbon dioxide emissions. Absent significant steps to reduce $CO_2$ emissions caused by concrete products and the construction projects they form, meeting ambitious climate change goals will be extremely difficult.

As global demand for infrastructure and building projects increases, green public procurement will play a critical role in driving demand for low-carbon concrete in order to reduce the sector's carbon footprint. To facilitate a concerted campaign for low-carbon concrete and construction procurement, the Concrete Action for Climate (CAC) Initiative, a coalition led by the World Economic Forum and Global Cement and Concrete Association (GCCA), has collaborated with Boston Consulting Group (BCG) to jointly author this *Low-Carbon Concrete and Construction: A Review of Green Public Procurement Programmes* report. CAC was formed as part of the Mission Possible Partnership (MPP), an alliance of climate leaders focused on supercharging decarbonization throughout the entire value chain of the world's highest-emitting industries in the next ten years.

This paper builds on previous publications – such as the Forum's and BCG's *Green Public Procurement: Catalysing the Net-Zero Economy* white paper and GCCA's *Concrete Future – The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete* – and examines the strategies and policies of six countries that are leading the procurement of low-carbon concrete and green construction.

We aimed to capture in one place low-carbon procurement efforts already underway in order to provide constructive ideas for policy-makers, building regulators and procurement offices as they create their own frameworks, tools and policies to meet climate change requirements.

The report's analysis is intended to assist public and private sector leaders in making design choices for data collection systems, developing baselines, and establishing targets and procurement models to reduce embodied carbon in concrete and construction projects. It also aims to support increased international collaboration in designing such systems and overcoming existing challenges. Furthermore, we hope this report will inspire construction industry business leaders to support a shift to low-carbon concrete and design green procurement ecosystems that can meet the anticipated growing demand for these products.

# EXECUTIVE SUMMARY

## A two-pronged approach exists to quantify and procure low-carbon concrete and construction projects in order to reduce carbon emissions

Michael Sidharta, GCCA Concrete in Life 2021 Photography Competition

Concrete is the world's most widely consumed human-made material. Because it is relatively inexpensive, strong and durable, concrete is a critical element in global economic and social progress. It supports the building of critical infrastructure that ultimately improves the health, mobility, education and sanitation of communities and creates millions of jobs. Moreover, as part of a finished project – such as a large building – concrete creates long-lasting, well-insulated structures that support the environment by reducing construction waste and energy use.

Yet, despite these many positive characteristics, there is a serious challenge to overcome: cement, the key ingredient in concrete, is responsible for roughly 7% of global carbon dioxide emissions. Consequently, strong and well-designed governmental requirements must stimulate demand for low-carbon concrete and construction to meet climate change goals. These policies need to address public sector construction, which is responsible 40% to 60% of concrete sales, and private sector construction. (A broad framework for low-carbon public procurement is described in the *Green Public Procurement: Catalysing the Net-Zero Economy* white paper published by the World Economic Forum and Boston Consulting Group (BCG).)

To produce this report, interviews were conducted with public and private sector representatives from six countries (the Netherlands, Sweden, Germany, France, the United Kingdom and the United States, with a focus on selected states) and publicly available tools and policies related specifically to the procurement of construction and concrete were reviewed. Analysis of this research has identified two crucial aspects of low-carbon procurement programmes: a carbon reduction foundation and procurement policies.

- The **foundation** typically comprises a set of common standards for conducting life-cycle assessments of the carbon emissions of concrete and other building products and built projects. It generally includes a product database to collect and store carbon emissions information in a structured format. The foundation also includes industry averages and baselines for embodied carbon in concrete, often by strengths or applications. Databases and baselines can also be established for whole projects.

- **Procurement policies** determine rules for the disclosure of carbon in concrete products and projects, which helps to support the data collection needed for the foundation. Additionally, embodied carbon baselines from the foundation are used to set targets for carbon emissions reduction at product and project levels. In turn, mandates and incentives are designed to meet these low-carbon procurement targets.

In addition, significant challenges must be addressed to improve the effectiveness of carbon reduction procurement plans on a broader scale:

- **Efficacy.** Low-carbon concrete and construction procurement programmes in place today are only starting points in a long process. These programmes must constantly track progress and be refined and strengthened in order to achieve the necessary results.

- **On-site application.** In some countries, such as India, concrete is often purchased as cement and mixed on site. This increases the complexity of collecting data and setting low-carbon baselines.

- **Emerging markets.** Low-carbon procurement policies tend to be more prevalent in developed, wealthy nations, like European nations and the United States. It will be important to scale and adapt green public procurement tools and policies to meet the needs of developing countries as well.

- **International standards and coordination.** While international standards for environmental product declarations exist, comparability of data and terminology across regions remains challenging.

To meet climate change goals, the public procurement of green concrete and construction will be a required element. However, while some countries have made strides in this direction, they are relatively small. Much more needs to be done in the Netherlands, Sweden, Germany, France, the United Kingdom and the United States and certainly in the many regions where low-carbon concrete procurement is not a priority. Having different policies in each country is inefficient and not conducive to global cooperation. Instead, a foundation of common global green construction guidelines and standards is necessary to support the development of databases, calculation tools and carbon emissions baselines. And, in turn, these elements must be aligned with procurement practices that emphasize the increased disclosure of embodied carbon in concrete and projects and incentivize low-carbon design.

# PART 1 INTRODUCTION

Mario Pereda, GCCA Concrete in Life 2021 Photography Competition

Meeting ambitious climate change goals – specifically, limiting the global average temperature increase to 1.5°C above pre-industrial levels – will not be possible without taking significant steps to reduce $CO_2$ emissions in cement manufacturing. Cement is responsible for approximately 7% of global carbon dioxide emissions and it is also the key ingredient in concrete. Demand for concrete, already high, is forecast to continue to soar in the coming years on the wings of a global infrastructure and building boom driven by the expansion of both new and developed economies. Critical construction efforts that ultimately improve the quality of life for millions of people while creating a wealth of jobs are underway or planned.

Concrete also plays a relatively unheralded role in supporting circularity in construction, which involves maximizing reuse and recycling. First, waste materials from other processes, such as energy production, can be recycled and mixed into concrete, reducing the amount of cement used. Second, at the end of a building's life, concrete can be crushed and repurposed for use as a road base or even new concrete. This reduces the use of materials as well as waste and pollution and, in turn, carbon emissions, a primary cause of climate change.

The public sector accounts for 40% to 60% of concrete sales and 20% to 30% of construction industry revenues – and regulates a large part of the remaining concrete use through building codes and construction rules. Thus, the public sector can have a significant influence on reducing carbon emissions by shifting more rapidly to green procurement policies. In addition, the public sector can establish rules for calculating the aggregated potential climate impact of a completed project in order to support the measurement and mitigation of emissions from concrete and construction projects.

The cement and concrete industry itself is calling for changes to standards and public procurement to stimulate demand for low-carbon concrete and construction. For example, industry representatives asked for these key policies in the 2021 Global Cement and Concrete Association (GCCA) *Concrete Future – The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete* publication.

This report explores the activities of six countries leading the procurement of low-carbon concrete and green construction:

- The Netherlands
- Sweden
- Germany
- France
- The United Kingdom
- The United States

This report is the result of extensive interviews with public and private sector construction and procurement leaders in these countries, as well as an in-depth analysis of the tools and policies that they have adopted to support a shift to low-carbon concrete and projects. These leaders were asked about the origins and goals of their initiatives, the choices they made and why, the obstacles that got in their way and how they worked around them. From their responses, a blueprint has emerged for how to best design the public procurement of green construction.

Although this report focuses on wealthier nations, where many of the concrete carbon emissions rules are being promulgated, as part of the next phase of this research, the Concrete Action for Climate (CAC) Initiative (launched by the World Economic Forum and GCCA) and Boston Consulting Group (BCG) are looking at concrete use in emerging markets to better understand what is required to drive progress in the decarbonization of concrete and construction projects.

To the degree that this report is technical in nature, it is because the topic of reining in carbon emissions is a complex issue. By capturing in one place a detailed account of low-carbon procurement efforts already in motion, this report aims to provide frameworks and methods for others to emulate, improve upon, adopt in whole or in part, and consider when aligning with international standards.

# PART 2 CHALLENGES OF THE CONCRETE AND CONSTRUCTION SECTORS

Agung Lawerissa, GCCA Concrete in Life 2021 Photography Competition

Each building, facility or infrastructure project for which companies procure concrete and construction represents a unique set of conditions and requirements. This heterogeneity of applications and features makes it especially challenging to set meaningful climate targets and implement effective policy in these sectors.

Construction is a complex sector with many stakeholders – all of whom have to be satisfied to one degree or another – and with low margins and site-specific project characteristics. Virtually every build is unique. These elements plus the vast variety of types of projects – everything from low-rise housing to long-span bridges and from multi-storey offices and skyscrapers to pavements and schools – contribute to the complexity of sustainable procurement in construction. But on top of that, it is necessary to consider the additional special features of concrete when establishing low-carbon procurement policies.

For one thing, concrete can meet highly variable functional requirements driven by project constraints – such as strength and durability – through a wide (theoretically infinite) range of products. This makes it difficult to set standards, baselines and targets for embodied carbon (defined by European Norm (EN) 15804 modules A1–B5 and C1-C4, see Appendix figure 1) in cement and concrete. The construction phase may also require specific concrete properties; for instance, concrete may need to be pumped over long distances vertically or horizontally, be self-compacting or need to gain strength rapidly. These characteristics typically increase the $CO_2$ intensity of the materials. In addition, seasonality and temperature patterns can affect the availability of materials and impact the mix design required to achieve specific levels of performance. Design elements that specifically take advantage of environmentally advantageous concrete properties – such as durability, thermal capacity and airtightness – can lower operational $CO_2$.

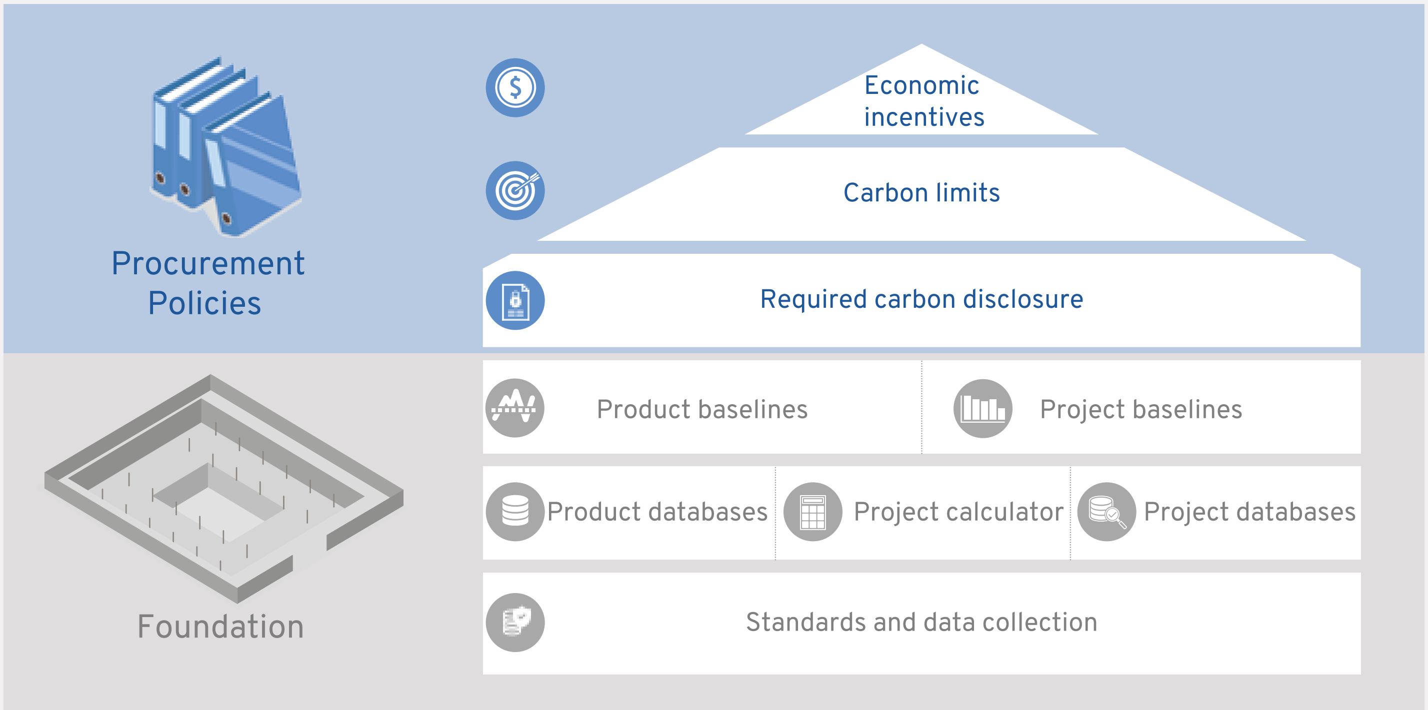
Shyjith Kannur, GCCA Concrete in Life 2021 Photography Competition

# PART 3 FRAMEWORK FOR LOW-CARBON PROCUREMENT

Based on the low-carbon concrete activities in the six-country analysis, a framework emerges for green procurement consisting of two essential elements:

- A **foundation** of carbon life-cycle assessment (LCA) standards, databases, calculation tools and carbon emissions baselines;
- **Procurement policies** that require embodied carbon disclosure and establish carbon reduction targets based on baselines from the foundation; these policies also limit embodied carbon in products or projects and can incentivize the low-carbon design of buildings and infrastructure projects.

**Figure 1 – Framework for low-carbon procurement of concrete and construction**



## 3.1 The foundation

The first phase of designing a complete data-driven foundation for the procurement of low-carbon concrete and construction involves:

- Aligning on common standards for performing the life-cycle assessment of products and projects;
- Creating a product database to collect and store the product information in a structured format, typically by gathering existing environmental product declarations (EPDs) and expanding datasets over time;
- Offering a project calculator, which can be fed by the product database, and assessing the life-cycle embodied carbon of projects to aid in the design of low-carbon projects;
- Establishing baselines (averages or reference points) for embodied carbon in concrete and ideally for built projects;
- Validating and storing project-level emissions in a project database that can be used to track progress in emissions reductions.

All six countries studied have adopted components of this foundation, although with some differences in approach:

- **Standards for life-cycle assessment:** All six countries have implemented European Norm (EN)/International Organization for Standardization (ISO) standards for concrete products and projects. These standards are the basis for carbon disclosures, often in the form of EPDs.
- **Product database:** All countries studied have or plan to implement some version of a building materials product database, which includes lifetime carbon emissions data for concrete products. The product databases of the Netherlands, Sweden, Germany and France were founded by governments. The United Kingdom's Built Environment Carbon Database (BECD) is being developed by a consortia of professional construction organizations. And the United States version, EC3, was founded by a non-profit and is currently available as a public beta test. While all databases are free to view, the Dutch database (Nationale Milieudatabase, NMD) and French database (INIES) charge a fee to add products.
- **Project database:** The United Kingdom and the United States have created project databases coupled with their product databases. In the United Kingdom, the Royal Institute of Chartered Surveyors (RICS) has developed the RICS Building Carbon Database, which collects embodied carbon data for buildings. This will become part of BECD once launched. BECD will include a project database for both buildings and infrastructure. EC3, based in the United States, also features a project database for buildings.

### Figure 2 – Product and project database examples

| Country | Database | Founder type | Database type | | Free offerings | |
|---|---|---|---|---|---|---|
| | | | Product | Project | Free to view | Free to add products |
| Netherlands | Nationale Milieudatabase | Government | ✓ | | ✓ | |
| Sweden | Boverket Klimatdatabas | Government | ✓ | | ✓ | ✓ |
| Germany | ÖKOBAUDAT | Government | ✓ | | ✓ | ✓ |
| France | INIES | Government | ✓ | | ✓ | |
| USA | EC3* | Non-profit | ✓ | ✓ | ✓ | ✓ |
| United Kingdom | Built Environment Carbon Database (BECD)** | Consortium of professional associations | ✓ | ✓ | ✓ | ✓ |

*In public beta test, not limited to United States market **Not yet live, expected to launch in late 2022

- **Project calculator:** The Netherlands, Sweden, Germany and the United Kingdom provide some form of government-developed project calculator (free except the Netherlands). The outputs of the calculators of the Netherlands and Germany are aligned with their respective public procurement scoring systems described in section 3.2 Procurement policies. The EC3 tool in the United States also includes a free calculator.

- **Product baselines:** Trade associations and certification bodies in Sweden, Germany, the United States and the United Kingdom have published concrete product baselines with varying approaches to setting baselines by strength, application and region (see Figure 3).

- **Project baselines:** The project baselines observed were generally released by government bodies alongside a set of targets and corresponding low-carbon procurement policy (described in section 3.2 Procurement policies), apart from the United Kingdom, where the Royal Institute of Chartered Surveyors has developed baselines by building type.

During the research and interviews for this report, four design considerations that must be given special attention in developing the foundation of a low-carbon concrete programme stood out: product categorization, comparability and specificity of EPDs, inclusion of operational carbon, and the role of governments.

- **Product categorization.** A critical decision in setting concrete baselines involves how to categorize concrete, with considerations between granularity and practicality of creating and maintaining baselines. The research identified baselines established based on strength, application and region. Application implicitly considers strength. Region is not mutually exclusive to strength or application.

  - **Strength.** Strength is a commonly used classification system for concrete and all examples noted in the report used included strength baseline parameters (either directly or through an application approach).

  - **Application.** An application approach can address strength, exposure class and other application-level requirements of concrete; however, establishing such baselines requires more effort than a purely strength-based approach.

  - **Country/region.** National/regional variations in concrete and building requirements drive differences in concrete and embodied carbon levels; as a result, national/regional baselines are useful. For example, the National Ready Mixed Concrete Association publishes baselines for 8 regions in the United States.

### Box 1 – Supplementary cementitious materials

A consideration when setting baselines is how to address supplementary cementitious materials (SCMs) because they have a significant impact on embodied carbon. This is true whether using strength or application categorization and true for all countries/regions.

Supplementary cementitious materials include ground limestone, natural and calcined pozzolans, as well as industrial by-products such as fly ash and GGBS (ground granulated blast-furnace slag).[1] SCMs are added by the cement manufacturer or at the concrete plant. One benefit of using SCMs to substitute for Portland clinker cement is a reduction in embodied carbon. Substitution levels can be as high 80%; but 15 to 50% is more usual as higher levels may reduce rate of strength gain of the concrete.

Two approaches are generally used to set baselines in this category:

- **Concrete using ordinary Portland cement (also known as CEM I) with no SCM**, which is more comparable across regions because it is a more consistent baseline relative to the alternative approach below

- **Concrete using an average or reference substitution level of SCM**, which reflects an embodied carbon figure closer to a concrete product but is less comparable between products and across countries/regions.

**Figure 3 – Product categorization examples for concrete baselines**

| Country | Product baseline publisher | Publisher type | Segmentation: Application | Segmentation: Strength | Segmentation: Region | Options to Address SCMs*: Concrete product with OPC** (CEM I) and no SCM | Options to Address SCMs*: Concrete product with average or reference % SCM |
|---|---|---|---|---|---|---|---|
| Sweden | Svensk Betong | Trade association | ✓ | | | | ✓ |
| Germany | Concrete Sustainability Council | Non-profit | | ✓ | | ✓ | |
| USA | National Ready Mixed Concrete Association | Trade association | | ✓ | ✓ | | ✓ |
| United Kingdom | Institute of Civil Engineers | Trade association | | ✓ | | ✓ | |

*SCM: supplementary cementitious materials **OPC: ordinary Portland cement

- **Comparability and specificity of EPDs.** EPDs are designed to compare functionally equivalent products – for instance, concrete beams having the same length, load capacity, expected service life, durability and fire resistance. The EPDs of these functionally equivalent products will be based on the same product category rules (PCRs). However, since PCRs vary by geography, comparisons of EPDs across regions are often flawed and should be used with some hesitancy when developing product baselines. Additionally, EPDs can range from generic to exceedingly specific, such as an EPD created by a specific supplier for a specific project at a given point in time. More specific EPDs are more accurate; however, generic data also plays an important role in the early design phase when specific suppliers and details are not yet known.

- **Inclusion of operational carbon.** When deriving baselines for built projects, it is critical to include both embodied and operational carbon. For example, a triple-glazed window would have a higher level of embodied carbon than a standard window due to the use of more materials; but operational carbon savings may outweigh this increase due to better insulation. By including operational carbon in life-cycle assessment calculations, databases, baselines and calculators can best support a government's overarching progress toward net-zero.

- **Role of governments.** Governments contribute a large share of construction sector revenues and thus can have substantial sway – both as makers of public policy and as customers – over ensuring that the standards, databases, tools, baselines and investment rationales for low-carbon cement products and projects are aligned. Broadly speaking, government leadership is required to create a cohesive sector-wide carbon reduction focus and to encourage and facilitate carbon data sharing across the value chain.

  For example, in the Netherlands, the Rijkswaterstaat and Dutch Public Procurement Expertise Centre, under the Ministry of Economic Affairs and Climate Policy, launched the Aanpak Duurzaam GWW (Sustainable GWW Approach), a programme that consists of four instruments to address sustainability goals in the procurement process. As another example, many of Sweden's green public procurement activities described in this report were formed to support the Swedish Climate Act, which set overarching country targets, including achieving net-zero by 2025, and established a government Climate Policy Council.

## 3.2 Procurement policies

The utility of standards, databases, tools and baselines for a low-carbon initiative can only be fully realized if they are actually implemented as part of a procurement programme. The policies observed to do this are: requiring embodied carbon disclosure, setting carbon limits, and providing economic incentives.

- **Requiring embodied carbon disclosure:** This is mandated for eligible products and projects in most of the countries in this report, typically in the form of EPDs. Eligible products and projects typically include those with some form of mandated limit on embodied carbon (described in next bullet). Looking ahead, the Industrial Deep Decarbonisation Initiative (IDDI), coordinated by the United Nations Industrial Development Organization (UNIDO), aims to secure commitments from at least ten countries to procure low-carbon steel and concrete within the next three years. Governments that sign onto this pledge will, at a minimum, agree to begin requiring disclosure of embodied carbon emissions of structural materials (such as steel, cement and concrete) used in major public construction projects by 2025.

- **Setting carbon limits:** In the research, three policy types for setting mandated product or project-level limits on embodied carbon were found (see Figure 4):

  - **Global warming potential (GWP).** GWP is a typical approach used for reporting embodied carbon levels. The Swedish Transport Administration (STA) and France's RE2020 regulation apply GWP limits at a project level. Boverket, the Swedish National Board of Housing, Building and Planning, also plans to introduce GWP limits as building codes by 2027. Notably, the STA sets its project baselines and limits on a case-by-case basis due to the complexity of establishing broad baselines for infrastructure projects. France's RE2020 policy is a building regulation that applies to new housing, offices and schools. The United States General Services Administration (GSA) and the State of California also set product-level GWP limits for eligible building products (California does not include concrete in eligible products but has drafted a proposal to do so). Other states, such as Colorado, have passed or proposed legislation similar to that of California.

  - **Carbon scoring systems.** The Netherlands project-level Environmental Performance of Buildings (known as MPG in Dutch) and Economic Cost Indicator (ECI in English or MKI in Dutch) systems use shadow costs for materials to calculate a single embodied carbon score at a project and product level respectively. A maximum MPG score is mandated for all new housing and offices (primarily impacting the private sector, given the building types). Additionally key government agencies responsible for public procurement have signed on to Betonakkoord (Concrete Agreement), a voluntary programme that sets published product-level limits on embodied carbon using the MKI score. Additionally, members agree to set project baselines and limits in a coordinated and uniform manner for both buildings and infrastructure projects.

  - **Blended scoring systems.** Germany's Assessment System for Sustainable Building (known as BNB in Germany) establishes a scoring mechanism with mandated maximum values by building type for projects procured by the Federal Ministry of the Interior, Building and Community. The scoring system considers GWP among dozens of other metrics related to environmental, social, building quality and other considerations, with GWP given a weight of 3.75%.

**Figure 4 – Carbon limit policy examples**

| Country | Policy type | Level | | System or policy | Applicable projects | |
|---|---|---|---|---|---|---|
| | | Product | Project | | Public | Private |
| Sweden | Global warming potential | | ✓ | Swedish Transport Administration global warming targets | ✓ | |
| France | Global warming potential | | ✓ | RE2020 | ✓ | ✓ |
| USA | Global warming potential | ✓ | | General Services Administration Low Embodied Concrete Standards, Buy Clean California Act, Buy Clean Colorado Act | ✓ | |
| Netherlands | Carbon scoring system | | ✓ | Environmental Performance of Buildings & Betonakkoord | ✓ | ✓ |
| Netherlands | Carbon scoring system | ✓ | | Economic Cost Indicator & Betonakkoord | ✓ | ✓ |
| Germany | Blended scoring system | | ✓ | The Assessment System for Sustainable Building | ✓ | |

Note: Examples represent particular government agencies and project types and are not applicable to all projects in the countries listed. Additional details on policies can be found in the appendix.

- **Providing economic incentives:** Monetary incentives for low-carbon performance – so-called green premiums – are crucial to providing a business case for suppliers of building materials and engineering and construction firms to invest in decarbonization technologies. The Netherlands, Sweden and several states in the United States have each taken a different approach to such incentives.
  - **Company performance score.** In the Netherlands, a tool known as the $CO_2$ Performance Ladder can be used to provide a fictitious discount on bid prices based on the climate ambition level in the project (and also organization). Under this system, levels 4 and 5 address supply chain decarbonization (scope 3 emissions) while levels 1 to 3 focus on activities within the organization or project, such as renewable energy use in company offices (scope 1 and 2 emissions). Discounts in the tender are specified by contracting authorities, with bigger discounts available to those at the higher levels on the ladder. The tool is used by over 200 contracting authorities, including the Directorate-General for Public Works and Water Management in the Netherlands (Rijkswaterstaat). SKAO, the non-profit that owns and operates the $CO_2$ Performance Ladder, has partnered with the IKEA Foundation to run pilot programmes for the $CO_2$ Performance Ladder in procurement offices in other countries.
- **Carbon abatement reward.** The Swedish Transport Administration awards contractors a bonus of up to 1% of the total project contract value for each tonne of $CO_2$ emissions abated below the maximum emissions requirement. Calculations are verified by independent certified institutes and penalties are applied if emissions reduction promises are not met.
- **Product and technology incentives.** In the United States, a proposed amendment to the Buy Clean California Act, if passed, would require awarding authorities to apply a fictitious discount to bids with GWP for concrete at least 10% below the average qualified bid. Additional fictitious discounts are proposed for bids for concrete produced using qualifying breakthrough technologies. New Jersey has drafted similar legislation that would, if passed, provide similar incentives in the form of tax credits.

### Box 2 – Connecting policy to the Paris Agreement

Generally, policies that require or incentivize the use of lower-carbon design and materials are not directly based on calculations derived from the Paris Agreement's commitment to limit the global temperature rise to 1.5° Celsius above pre-industrial levels. Rather, targets and policies typically seek to balance factors like ambition, feasibility and economics. As new green public procurement programmes are created and existing ones are refined, it is worth considering whether such policies are sufficiently ambitious to achieve the goals of the Paris Agreement.

Taking a more granular view, four potential challenges to setting carbon reduction targets and establishing procurement policies must be carefully considered. They involve: reference years, the interrelationship between carbon reduction percentage targets and volume impacted by targets, a whole project whole life carbon focus and case-by-case targets.

- **Reference years.** Setting climate-based targets at the concrete sector and project level often begins with establishing a reference against which emissions should be reduced over time. Global initiatives often reference the most recent year for which data is available as the baseline when establishing 2030 targets. In practice, the six countries in this report chose a variety of carbon baseline years. The Swedish Transport Administration's baseline year is 2015, while California's Buy Clean Act has a rolling baseline year, starting with 2022 and updated every 3 years. Other countries have opted for 1990 because it was the base year for their national greenhouse gas inventories and the initial calculation of assigned targets when the Kyoto Protocol was established.[2]

- **Interrelationship between carbon reduction percentage targets and volume impacted by targets.** At the cement sector level, a target of 20% absolute carbon reduction by 2030 vs 2020 can be met by either requiring 20% of sales volume to be made up of net-zero cement, 100% of sales volume composed of 20% carbon-reduced cement, or any combination in between. The choices of target carbon reduction and the volume of net-zero cement are thus entirely interrelated.

  As is true of any product, the percentage carbon reduction target should be set according to the type of decarbonization technologies possible, the extent of their coverage and the speed that these technologies can be developed. For example, carbon capture, utilization and storage (CCUS), a critical technology in delivering net-zero concrete, is not widely available at scale today. As this changes in the coming decade, low-carbon procurement targets can be adjusted. Importantly, the compromises in aggressive carbon reduction targets that may have to be made based on the technology available to achieve them should not be viewed as an "us vs them" dynamic. Rather, both sides – environmentalists and technologists – want to reduce carbon emissions.

- **Whole project whole life carbon reduction focus.** Regions may differ on the precise strategies they adopt but ensuring that policies consider a project's full carbon impact is imperative. Whole project carbon emissions should be given serious consideration to ensure that reducing $CO_2$ in materials does not compel design and structural decisions that could result in future operational or maintenance emissions in the finished project that outweigh any upfront carbon savings.

- **Case-by-case targets.** The development of carbon emissions baselines and targets on a project-specific basis (as seen in Sweden and the Netherlands) is an approach used in particular with infrastructure projects to address the unique nature and requirements of each project when setting project limits on embodied carbon. This approach is occasionally viewed as problematic because a lot of time may be spent calculating baselines rather than finding and implementing carbon reduction measures. However, it is a pragmatic way to address the one-of-a-kind nature of certain projects. To create guidelines for establishing case-by-case targets, the Swedish Transport Administration uses a standard percentage reduction target against its bespoke baselines and the Netherlands has developed a standard approach to developing case-by-case baselines described in appendix section B II on setting carbon limits.

**Figure 5 – Observations of leading low-carbon concrete foundations and procurement policies**

### Product categorization

Set categories by strength or application (for example precast concrete product) in accordance with regional practices

### Setting project baselines

Take a whole life whole carbon approach including embodied and operational carbon and set baselines by project type, with adjustments for specific cases, especially non-building infrastructure projects

### Role of governments

Play a leading role in orchestrating the components supporting the procurement of low-carbon concrete and construction

### Carbon disclosure

Require verified EPDs for products and aggregate these together with operational carbon emissions data for project comparisons, recognizing that different PCRs and EPD rules mean that EPDs are not always comparable

### Reference years

Select a baseline year, recognizing that the year is fully interrelated with % target reductions (2020 is typically the most recent data available at this time)

### Incentivizing low-carbon performance

Provide monetary incentives (e.g. green premiums) for low-carbon performance

### Carbon reduction target on product sector level

Choose % carbon reduction target as a function of:

- Proportion of total production volume that is in scope of the procurement initiative
- Reference year and target year
- Achievability by supply industry to ensure initiative is credible
- Strength of demand signal required to support transition in accordance with net-zero transition (for example, GCCA global roadmap aligns with Paris Agreement)

# PART 4 AREAS NEEDING FURTHER CONSIDERATION

Agung Lawerissa, GCCA Concrete in Life 2021 Photography Competition

Although the Netherlands, Sweden, Germany, France, the United Kingdom and the United States have made a lot of progress, this is just the beginning. Challenges still impede the programmes and policies in the countries working the hardest to address the procurement of low-carbon concrete and construction. And further challenges exist in expanding low-carbon procurement programmes to other countries. Among these challenges:

- **Efficacy.** While creating databases, setting baselines and implementing incentives are intuitively steps in the right direction, more time and effort should be invested in studying these approaches to determine how they can meaningfully, consistently and effectively contribute to achieving countries' climate targets. It will be important for countries to measure the impact of these programmes and diligently refine systems and policies in order to achieve the necessary results.

- **On-site application.** The tools described in this paper have largely been designed for the purchase of concrete. However, in some economies – such as India, the second largest cement producer after China – concrete is often not purchased as ready-mixed or precast concrete but as bagged cement to be mixed on the project site. This means that the tools for setting product and project baselines described in this paper may not be directly transferable. While markets like India are quickly moving toward a higher share of ready-mixed concrete, it is important to better understand the use and applications of concrete in these markets in order to further the ambitions and goals of green procurement. CAC (a joint initiative between the Forum and GCCA) and BCG will undertake an analysis of this topic later in 2022.

- **Emerging markets.** The concrete procurement policies discussed in this report are increasingly being implemented in the United States and developed European nations. It will be important to scale and adapt green public procurement systems to be suitable for developing nations, where a large share of global construction will take place in the coming decades.

- **International standards and coordination.** International standard definitions for product category rules, project-level carbon assessments, and low-carbon concrete are important to enabling the scaling and use of low-carbon procurement programmes and to supporting international collaboration to decarbonize concrete. International (ISO) and European (EN) standards exist for environmental product declarations. However, further work is needed to clarify best practices for practical applications to enable better international collaboration and comparability.

# PART 5 CONCLUSION

@abemotomoto, GCCA Concrete in Life 2021 Photography Competition

The low-carbon concrete and construction framework – comprised of a foundation and procurement policies – is not a silver bullet but rather the beginning of an essential process. To meet climate change goals, public procurement of green construction will be a required element. Consequently, the tools and systems are a useful snapshot of how six countries are dealing with this urgent issue. Hopefully, their experiences and the challenges they face – and the ways they are working to overcome obstacles – can serve as a model for other countries, the private sector and global collaboration.

As more and more low-carbon concrete policies are adopted, they will need to be continuously evaluated and tweaked to ensure that progress is being made on clear targets that align with the aspirations of 1.5° Celsius and net-zero commitments. As advances in the manufacturing of cement occur, including carbon sequestration and storage technologies, these targets can become even more ambitious.

Challenges remain, of course, including understanding programme effectiveness, setting meaningful baselines, and addressing regional variations in standards and uses of concrete. But like most other paths towards a goal, those to public procurement of low-carbon concrete and green construction need clear and direct roadmaps. The foundation must be made of carefully designed standards, databases, calculation tools and emissions baselines. Procurement policies, fed by critical elements of the foundation, should be designed to provide transparent disclosure of embodied carbon in concrete and projects, set ambitious but credible targets, and provide incentives for low-carbon design.

# APPENDIX:
## A CLOSER LOOK AT THE RESEARCH

Niyazi Gürgen, GCCA Concrete in Life 2021 Photography Competition

This section examines the degree to which the six countries are implementing the elements of 1) building a foundation of standards, databases, tools and baselines and 2) using this foundation to set emissions targets and incentives in procurement.

## A. The foundation

### I. Standards for life-cycle assessment and carbon disclosure

Standards are essential to performing a life-cycle assessment (LCA) of the environmental impacts of products and projects and ensuring comparability in databases, baselines and targets. One set of standards, designed by the International Organization for Standardization (ISO), includes ISO 14025, ISO 14040, ISO 14044, ISO 21930 and ISO 21931. The most common method to report the results of LCAs involves environmental product declarations (EPDs), which are developed according to a set of requirements known as product category rules (PCR). In EPDs, embodied carbon information can be found under the “Global warming potential (GWP) in kg $CO_2$ equivalent” heading. EPD programme operators, such as the Institut Bauen und Umwelt in Germany or EPD International in Sweden, maintain product category rules.

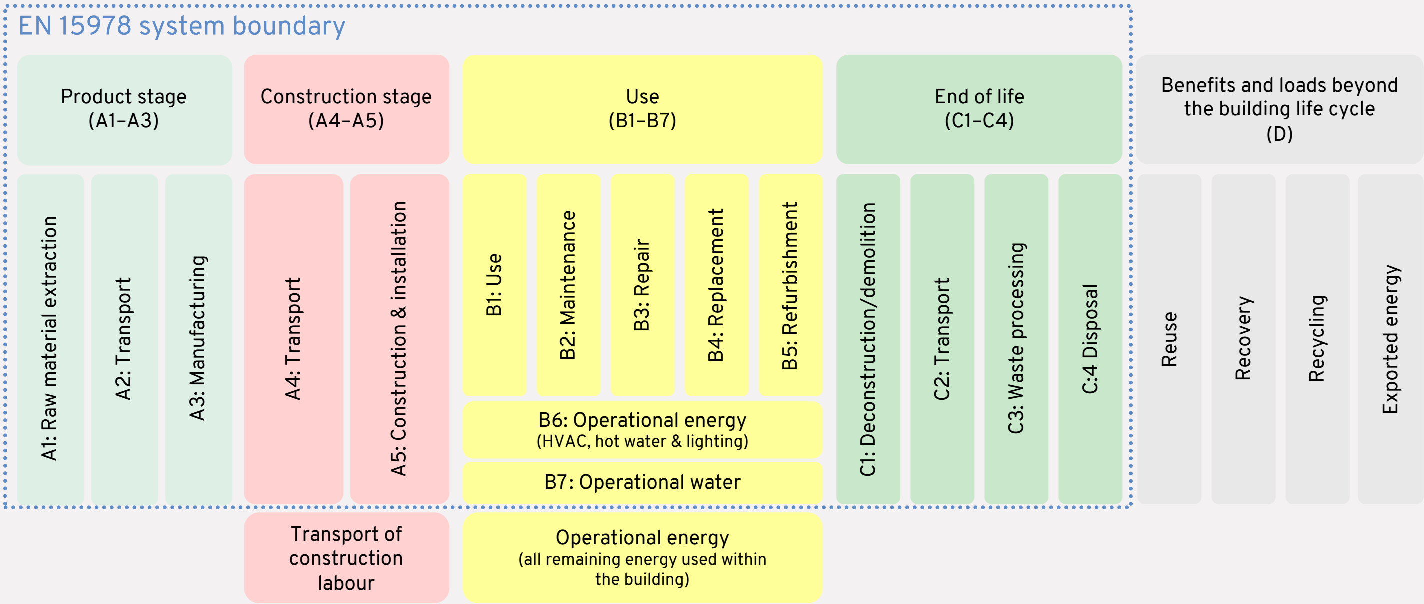
European standard EN 15804 covers product category rules to develop EPDs for construction products, while EN 15978 and EN 15643 provide frameworks to perform LCAs for buildings and infrastructure projects, respectively (see Appendix figures 1, 2 and 3). These standards are consistent with ISO standards (see Appendix figure 4).[3]

**Appendix figure 1 – Environmental product declarations – Core rules for the product category of construction products - EN 15804**

| | Life-cycle stages | Product | | | Construction | | Use stage | | | | | | | End-of-life | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Related to building fabric | | | | | Related to building operation | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 |
| | Modules | Raw material supply | Transport | Manufacturing | Transport | Construction | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | Demolition | Transport | Waste processing | Disposal |
| | | | | | Scenarios | | | | | | | | | | | | |
| Type of EPD | Cradle to gate | M | M | M | | | | | | | | | | | | | |
| | Cradle to gate with option(s) | M | M | M | O | O | O | O | O | O | O | O | O | O | O | O | O |
| | Cradle to grave | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M |

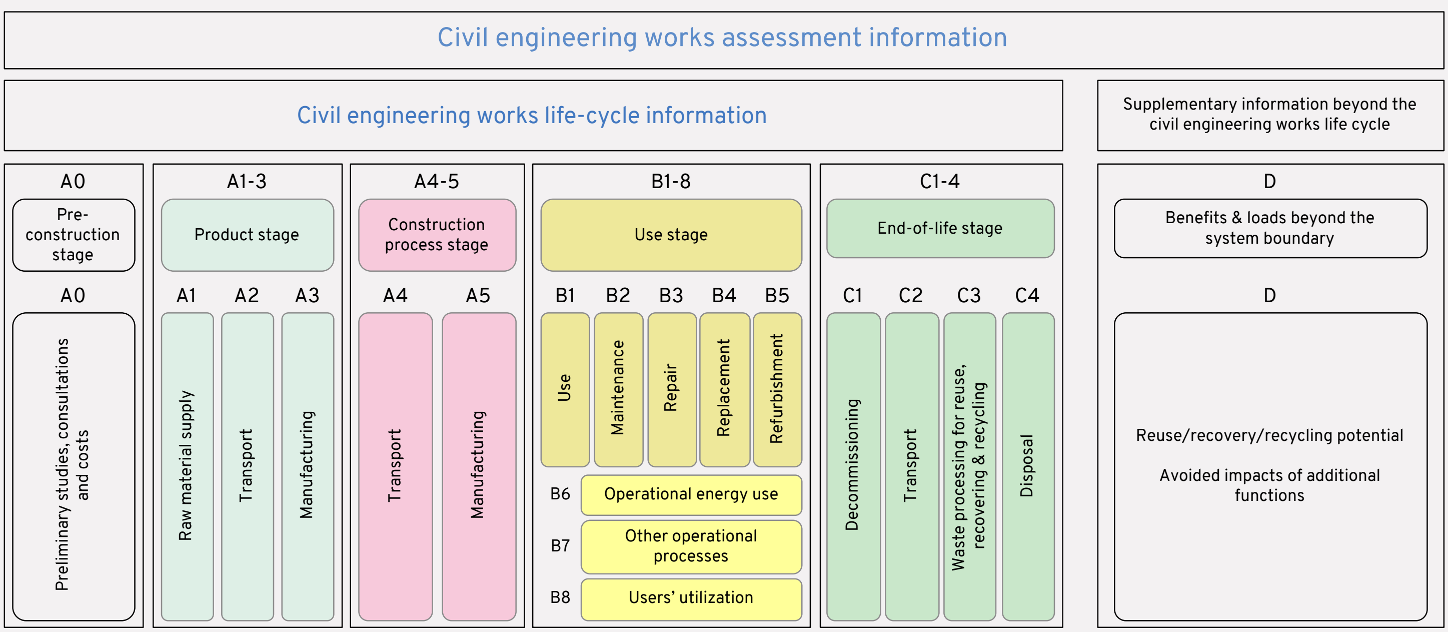
Source: eToolLCD, eToolLCD: Compliance with International Standards, 2020, https://support.etoollcd.com/index.php/knowledgebase/etoollcd-compliance-with-international-standards/.

### Appendix figure 2 – Assessment of environmental performance of buildings – Calculation method EN 15978



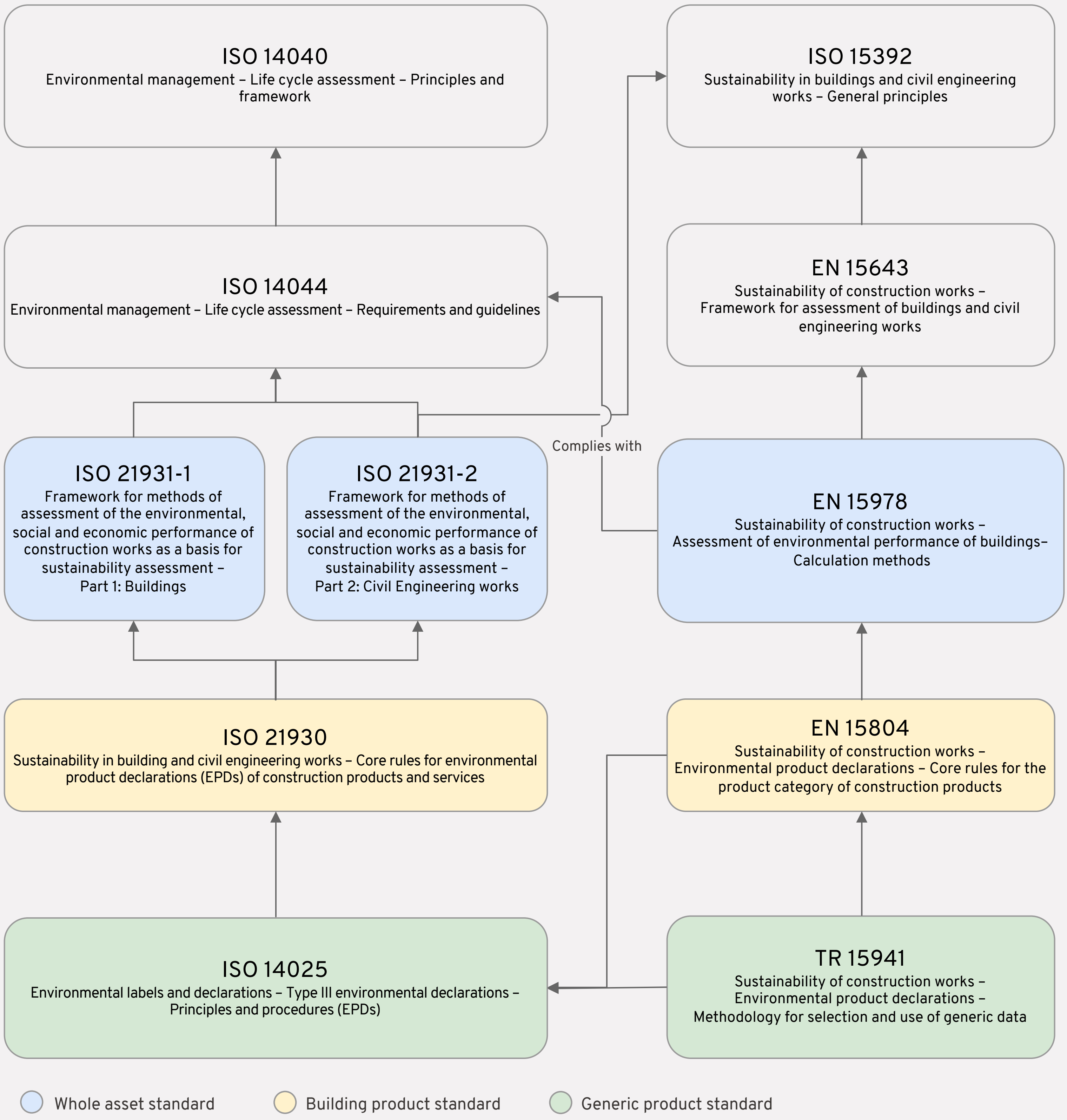

Source: eToolLCD, eToolLCD: Compliance with International Standards, 2020, https://support.etoollcd.com/index.php/knowledgebase/etoollcd-compliance-with-international-standards/.

### Appendix figure 3 – Framework for assessment of buildings and civil engineering works - EN 15643




Source: eToolLCD, eToolLCD: Compliance with International Standards, 2020, https://support.etoollcd.com/index.php/knowledgebase/etoollcd-compliance-with-international-standards/.

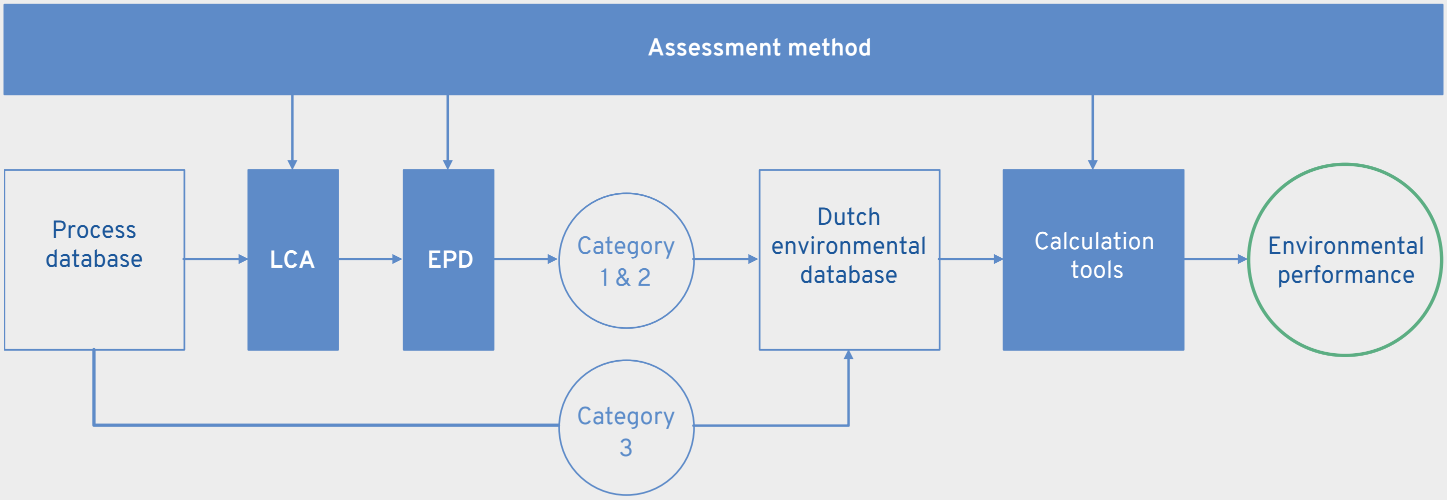
**Appendix figure 4 – Summary of interactions between ISO, EN and TR standards**




Source: eToolLCD, eToolLCD: Compliance with International Standards, 2020, https://support.etoollcd.com/index.php/knowledgebase/etoollcd-compliance-with-international-standards/.

– **Product database.** The Dutch Environmental Database (Nationale Milieudatabase, NMD) was created and is managed by the National Environmental Database Foundation, an independent organization that also oversees and maintains the method of the Environmental Performance of Buildings (MPG) measurement system (see Appendix figure 5). This determination method is based on European standard EN 15804 and includes product category rules (PCR) for all construction products and construction installations and calculation rules for assessing the environmental performance of construction works. The database includes three categories of data: (1) brand-specific data provided by the manufacturer or producer; (2) unbranded data provided by the Dutch market or manufacturers' groups; and (3) unbranded data drafted by LCA experts under the responsibility of the Dutch Environmental Database .

**Appendix figure 5 – Method used to indicate environmental performance of built projects in the Netherlands**




Source: Nationale MilieuDatabase (Dutch National Environmental Database Foundation), An introduction to the Dutch system of environmental performance of construction works, https://milieudatabase.nl/en/about-us/an-introduction-to-the-nmd/.

– **Project calculator.** The NMD provides calculation rules to indicate how the determination method should be converted into a digital instrument and validates government-developed and private sector calculation software to analyse the performance of construction projects based on NMD environmental data. The list of validated calculation tools includes DuboCalc developed by the Directorate-General for Public Works and Water Management in the Netherlands (Rijkswaterstaat).[4]

The environmental performance calculation produces scores aligned with the procurement policies described in more detail in section B II on setting carbon limits below. Scores are calculated by weighting categorical environmental impacts to result in an aggregated value – a single-score indicator (see Appendix figure 6) – for the environmental performance of a product (an environmental cost indicator – ECI or MKI in Dutch). For buildings, the sum of the product ECIs can then be converted into an Environmental Performance of Buildings (MPG in Dutch) single score for a construction project per m$^2$ per year. While the database and its approximately 3,400 product cards can be viewed for free online, there is a fee for the use of the data in online and validated calculation tools and for suppliers to add products.

### Appendix figure 6 – Netherlands ECI single-score indicator criteria

| Impact category | Unit | Weighting of results |
|---|---|---|
| Climate change – total | kg $CO_2$-eq. | |
| Climate change – fossil | kg $CO_2$-eq. | |
| Climate change – biogenic | kg $CO_2$-eq. | |
| Climate change – land use and change to land use | kg $CO_2$-eq. | |
| Ozone layer depletion | kg CFC-11-eq. | |
| Acidification | mol H+-eq. | |
| Freshwater eutrophication | kg $PO_4$-eq. | |
| Seawater eutrophication | kg N-eq. | |
| Land eutrophication | mol N-eq. | |
| Photochemical ozone formation | kg NMVOC-eq. | → Single-score indicator |
| Depletion of abiotic raw materials, minerals and metals | kg Sb-eq. | |
| Depletion of abiotic raw materials fossil fuels | MJ, net cal. val. | |
| Water use | $m^3$ world eq. | |
| Fine particulate emissions | Illness incidence | |
| Ionizing radiation | kBq U235-eq. | |
| Ecotoxicity (freshwater) | CTUe | |
| Human toxicity, carcinogenic | CTUh | |
| Human toxicity, non-carcinogenic | CTUh | |
| Land-use related impact/soil quality | Dimensionless | |

Source: Nationale MilieuDatabase (Dutch National Environmental Database Foundation), An introduction to the Dutch system of environmental performance of construction works, https://milieudatabase.nl/en/about-us/an-introduction-to-the-nmd/.

## Sweden

- **Product database.** The National Board of Housing, Buildings and Planning (Boverket) provides a climate database (Klimatdatabas) with 170 generic building resources.

- **Project calculator.** The non-profit IVL Swedish Environmental Research has developed an LCA calculation tool known as Byggsektorns Miljöberäkningssystem (BM) for buildings with both paid and free licenses available. Additionally, the Swedish Transport Administration (Trafikverkets) owns and maintains Klimatkalkyl, a free tool for project-specific climate calculations of energy use and climate impact from a life-cycle perspective.

## Germany

- **Product database.** The ÖKOBAUDAT is a database for the environmental evaluations of buildings by the German Federal Ministry of the Interior, Building and Community. The ÖKOBAUDAT has approximately 1,400 datasets for building products that are compliant with EN 15804 and the Assessment System for Sustainable Building (Bewertungssystem Nachhaltiges Bauen, BNB) and serves as the mandatory database for BNB (described in more detail in section B II on setting carbon limits below). ÖKOBAUDAT is based on the GaBi (LCA) background database and datasets can either be from (1) EPD generated in the framework of an EPD programme, (2) third-party verified LCA data that was not generated in an EPD programme or (3) generic LCA data. The Federal Ministry of the Interior, Building and Community provides the ÖKOBAUDAT data free of charge and without any restrictions.

- **Project calculator.** eLCA software is an online life-cycle assessment tool for buildings based on the ÖKOBAUDAT datasets. Users can model building components – for instance, dimensions – and calculate environmental effects derived from the amount of building construction that these components represent and the operational energy needed. Project results are then shown as a percentage of the benchmark in assessment systems (BNB). The basis for the calculation and assessment is the calculation rules of the BNB system (more details in section B II on setting carbon limits below).

## France

- **Product database.** The INIES database is the French national reference database on environmental and health data for construction products and equipment. It provides environmental and health declaration sheets (FDES, which include environmental declarations and additional health information) for construction products and product environmental profiles (PEP) for building equipment. Data is collected from manufacturers or professional unions in the format of European standard NF EN 15804 and its national supplement for construction products, and the NF XP C08-100-1 standard and PCR ed.3 for equipment. The INIES database is managed by the Supervisory Board and the Technical Committee, appointed by the Ministry of Construction.[5] Suppliers pay a fee for each product they add to the database.

## United Kingdom

- **Product and project database.** A consortium of professional organizations in the United Kingdom building sector will be launching the Built Environment Carbon Database (BECD) in 2022 for product and project carbon estimating and benchmarking. The free database will be developed to collect and supply product and entity (project) data to the industry through its own portal and by interacting with existing databases and software solutions. The entity-level data will store whole life carbon emissions assessed at the level of buildings and infrastructure and will structure the data according to the EN 15978 and EN 17472 standards (including both embodied and operational carbon). The product-level data will store whole life carbon emissions assessed at the level of construction materials, products and works and will organize the data according to the EN 15804 standard. Classification by object type (e.g. dense concrete block) will enable users to generate typical embodied carbon ranges for construction products and works.[6]
- **Project calculator.** United Kingdom calculation tools include the Rail Carbon Tool (sponsored by the non-profit Rail Safety and Standards Board), which calculates the carbon footprint of rail projects in the United Kingdom and identifies alternative low-carbon options, the Carbon Tool (developed by government agency Highways England), which calculates carbon emissions for the agency's roadways operational, construction and maintenance activities, and the Carbon Planning Tool (developed by the Environment Agency), which is mandated for use on all environment agency projects.[7]

## United States

- **Product database and project calculator.** The Embodied Carbon in Construction Calculator (EC3), developed by the non-profit Building Transparency, can be used for benchmarking and assessment of embodied carbon in construction materials. The tool is free and uses building material quantities from construction estimates and/or building information models and third-party verified EPDs. EC3 launched in 2019 and is designed to be open and interoperable with other platforms and not limited to serving the market in the United States.
- EC3 consists of a database of building material EPDs, including concrete, steel, aluminium and wood. As of February 2022, there were 36,000 digitized verified EPDs for concrete in the database. Users can compare embodied carbon in concrete in several ways – by categories (e.g. ready-mixed or shotcrete), United States regions, manufacturers or strength. A search for 5000 psi ready-mixed concrete in California, for example, shows the number of EPDs and average embodied carbon for these parameters. The EC3 tool leverages the building materials EPD database to assess a built project's overall embodied carbon emissions. The tool is currently in a public beta test.

## III. Baselines for embodied carbon

### Germany: Product baselines developed by non-profit and project baselines developed by government

The Concrete Sustainability Council (CSC) has published a methodology for reference values and targets for global warming potential levels for six categories of concrete strength as part of the new $CO_2$ module that it launched in January 2022 (see Appendix figure 7) for Germany and Belgium. In setting the benchmarks, two critical decisions were made. First, to use a CEM I mix without any supplementary cementitious material to intentionally rely on a common and clear calculation basis. Second, to start target reduction levels at an ambitious level of 30%, which is high enough to incentivize investment in breakthrough technologies such as carbon capture, utilization and storage (CCUS).

**Appendix figure 7 – Concrete Sustainability Council reference values and targets**

| $CO_2$\strength classes | C20/25 | C25/30 | C30/37 | C35/45 | C45/55 | C50/60 |
|---|---|---|---|---|---|---|
| Maximum greenhouse gas emissions per reduction level [net kg $CO_2$eq. / $m^3$]* | | | | | | |
| Reference values | 213 | 237 | 261 | 286 | 312 | 325 |
| Level 1 (↓≥ 30%) | 149 | 166 | 183 | 200 | 218 | 228 |
| Level 2 (↓≥ 40%) | 128 | 142 | 157 | 172 | 187 | 195 |
| Level 3 (↓≥ 50%) | 107 | 119 | 131 | 143 | 156 | 163 |
| Level 4 (↓≥ 60%) | 85 | 95 | 104 | 114 | 125 | 130 |

*See the CSC background report on the reference values for information on the use of Ecoinvent background datasets for aggregates and transport at https://www.csc-zertifizierung.de/downloads/.
Source: Concrete Sustainability Council, $CO_2$-Module: Annex, 2022.

For projects, the Federal Building Ministry launched the Assessment System for Sustainable Building (Bewertungssystem Nachhaltiges Bauen, BNB), a reference baseline established by building type (see section B II on setting carbon limits below for more details on the BNB system).

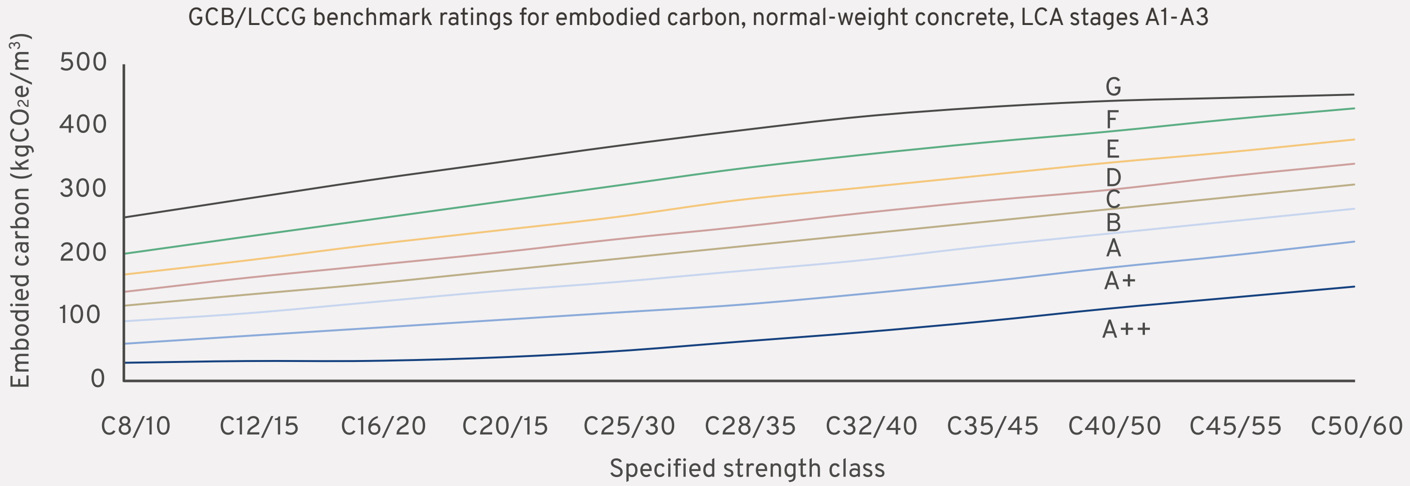
### Sweden: Product baselines developed by trade association

The Swedish Concrete Association (Svensk Betong), an industry organization for companies that manufacture ready-mixed concrete and pump concrete, and make or assemble concrete products, has published a baseline and possible emissions targets by concrete applications. According to the trade group, a 10% embodied emissions reduction in concrete compared to industry reference can be achieved through optimized binder composition without any significant impact on the product's properties. A 25% to 40% reduction is achievable but would require a joint effort among the client, designer, contractor and supplier to ensure that the concrete meets intended quality and function standards.

### United Kingdom: Product and project baselines developed by trade associations

The Institution of Civil Engineers (ICE) published a report in 2022 that includes carbon emissions baselines of concrete by strength. The report sets benchmarks by fractile (see Appendix figure 8).

### Appendix figure 8 – Institution of Civil Engineers carbon emissions baselines by strength




Notes

- The benchmark ratings are based on embodied carbon of normal weight concrete mixes used recently in the United Kingdom
- Performance requirements may make it impractical to achieve some ratings for a particular application
- Achieving rating of A, A+ or A++ through use of a high proportion of GGBS with an associated requirement to significantly increase the total binder content (kg/m³) may not be an effective method of reducing global GHG emissions
- Opportunities to reduce the carbon rating may typically be achieved by adjusting type and % of SCM, requirements for early strength gain, consistency, environment (e.g. by use of protective barrier layers), minimum cement content (kg/m³), w/c ratio, use of admixtures, type and grading of aggregates, age at which the specific strength must be achieved, sources of constituents

### Distribution of kg $CO_2e/m^3$ to different fractiles for a given strength class

| Rating | kg $CO_2e/m^3$ fractile range within the strength class |
|---|---|
| A++ | kg $CO_2e/m^3$ below those of benchmarked concretes |
| A+ | 0-5% |
| A | 5-20% |
| B | 20-40% |
| C | 40-60% |
| D | 60-80% |
| E | 80-95% |
| F | 95-100% |
| G | kg $CO_2e/m^3$ above those of benchmarked concretes |

Carbon intensity increases with fractile. Generally, for a given strength class, concretes in higher fractiles make less use of SCMs to replace Portland cement (CEM I) and/or include a higher total cement content (kg/m³).

Source: Institution of Civil Engineers, Low Carbon Concrete Group and The Green Construction Board, Low Carbon Concrete Routemap, n.d., https://www.ice.org.uk/engineering-resources/briefing-sheets/low-carbon-concrete-routemap.

The Royal Institution of Chartered Surveyors (RICS) has launched a whole life Building Carbon Database that includes average embodied carbon levels by building type (see Appendix figure 9).

This database will be replaced by the Built Environmental Carbon Database (BECD) once it is launched in 2022.

**Appendix figure 9 – Royal Institution of Chartered Surveyors Building Carbon Database GWP by building type**

| Building use | Average ($kgCO_2e/m^2$) | Min ($kgCO_2e/m^2$) | Max ($kgCO_2e/m^2$) | 1 standard deviation ($kgCO_2e/m^2$) | Number of records |
|---|---|---|---|---|---|
| Offices | 846 | 0 | 4191 | 679 | 83 |
| Retail | 4949 | 241 | 20640 | 6173 | 13 |
| Residential | 905 | 0 | 2456 | 644 | 64 |
| Educational | 500 | 342 | 959 | 168 | 29 |
| Healthcare | 392 | 139 | 513 | 81 | 20 |
| Recreational | 597 | 597 | 597 | 0 | 1 |
| Multi-use | 653 | 0 | 1891 | 629 | 11 |
| Car parking | 545 | 545 | 545 | 0 | 1 |
| Factories | 703 | 703 | 703 | 0 | 1 |
| Warehouses | 629 | 538 | 779 | 131 | 3 |
| Stations | 445 | 95 | 794 | 494 | 2 |
| Churches/chapels/ mosques/temples | 0 | 0 | 0 | 0 | 1 |
| Ambulance stations | -23 | -23 | -23 | 0 | 1 |
| Other | 0 | 0 | 0 | 0 | 7 |
| Commercial | 57 | 57 | 57 | 0 | 1 |

Source: Royal Institute of Chartered Surveyors, "RICS Building Carbon Database", as consulted in January 2020, https://www.rics.org/uk/products/data-products/insights/rics-building-carbon-database/.

## United States: Product baselines developed by trade association

The National Ready Mixed Concrete Association (NRMCA) published baselines for ready-mixed concrete manufactured by NRMCA members in a 2020 report prepared by the Athena Sustainable Materials Institute. The report presents life-cycle impact assessments for both the United States as a whole and eight NRMCA regions of nine benchmark ready-mixed concrete products, which vary by compressive strength and cementitious material content.[8]

## B. Procurement policies

### I. Requiring embodied carbon disclosure

As of 1 January 2022, Sweden's National Board of Housing, Buildings and Planning (Boverket) is compelling A1-A5 climate declarations for most houses and dwellings prior to building. The use of specific emissions data is recommended and a 25% penalty is applied to builders that only provide generic emissions data. Similarly, the Swedish Transport Administration (Trafikverkets, STA) requires the use of its climate calculator (Klimatalkyl) for planning and early design contracts on projects budgeted at above €5 million. In addition, a climate declaration to demonstrate achieved embodied carbon emissions reductions must be made for finished facilities. For projects with a budget below €5 million, EPDs are required at the product level for cement, concrete, reinforcement and construction steel.

Similarly, the Netherlands, France, Germany, and California and Colorado in the United States compel carbon disclosure by requiring EPDs on eligible projects.

### II. Setting carbon limits

#### Netherlands: Carbon scoring systems

The Betonakkoord (Concrete Agreement in English) initiative is a non-profit-led voluntary commitment that key government agencies (as well as some private companies) have joined. It sets maximum MKI values (more details on MKI in section A II on databases and calculators above) for concrete by strength and select product categories. The Betonakkoord was initiated through the $CO_2$ Performance Ladder. These targets are scheduled to decline every two years. Additionally, Rijkswaterstaat, the Directorate-General for Public Works and Water Management, has set MKI limits for its own procurement by application, with a declining schedule through 2030.

On a building level, the Dutch national building legislation sets a maximum value of 0.8 MPG (more details on MPG in section A II on databases and calculators above) for new houses and office buildings (public and private). The aim is to gradually reduce the threshold to at least 0.5 by 2030. For civil infrastructure, no mandated threshold exists; however, members of the Betonakkoord have agreed to apply limits in tenders and to do so in a coordinated and uniform effort.

For cases where limits are set case-by-case, the Dutch Public Works Agency and Public Procurement Expertise Centre (PIANOo) have developed a method to determine carbon targets in the procurement process consisting of four instruments: Omgevingswijzer (Environmental Compass), Ambitieweb (Ambition Monitor), $CO_2$ Performance Ladder and a calculator, DuboCalc. These four instruments were developed as part of the Netherlands Green Deal Aanpak Duurzaam GWW (Sustainable GWW Approach) and are used by both private and public sector organizations.

The Omgevingswijzer (Environmental Compass) analyses several sustainability factors and compares possible solutions; it is used in the preliminary stages of a project when the location is chosen but several options related to scope and materials are still to be decided. Building on the results of the Omgevingswijzer, the Ambitieweb (Ambition monitor) is a tool for determining possible carbon reduction levels within the project scope. The outcome from the Ambitieweb, in turn, is plugged into the $CO_2$ Performance Ladder and DuboCalc tool to come up with the most economically advantageous tender (MEAT) or maximum value for the project in terms of sustainability.

From these calculations, the contracting agency sets a carbon reduction target range for the project. The agency then monetizes the proposed sustainability improvements, among other things, and subtracts the value of these improvements from the price of the bid.

#### Sweden: GWP limit

The Swedish Transport Administration (STA) has set a series of global warming targets (compared against 2015 baselines) and corresponding bonuses for projects that it awards:

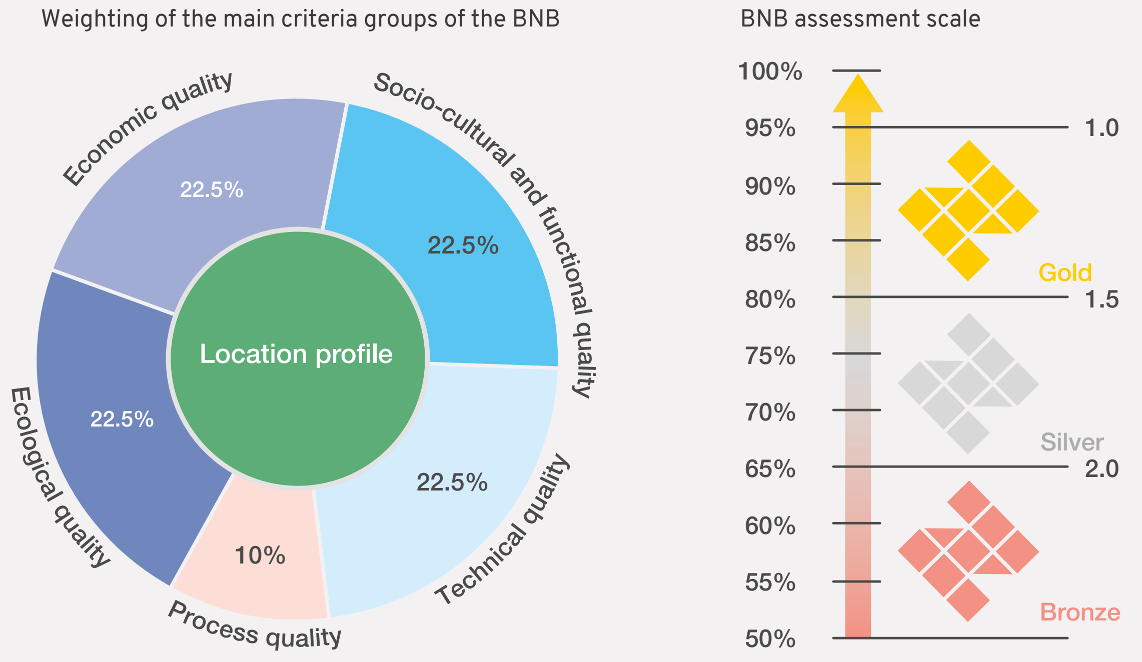
- 2020–2024: a minimum 15% reduction in climate impact with a bonus for reductions in projects and railway equipment;
- 2025–2029: a minimum 30% reduction in climate impact with a bonus for reductions of up to 50%;
- 2030–2034: a minimum 50% reduction in climate impact with a bonus for reductions of up to 100%. Fossil-free fuels or electric propulsion in all contracts.
- 2045: climate neutral
- Interim targets for 2035 and 2040 to be provided in 2022

For each project, consultants develop carbon baselines in the planning or design phase using STA's climate calculation tool (Klimatkalkyl). The tool calculates embodied carbon from assigned materials and construction activities using emissions factors described for "business as usual" technology in 2015. If detailed quantities are not known the tool also includes templates for different construction elements (e.g. a railway bridge, a road tunnel, etc.) based on values from previous projects. STA then specifies the carbon reduction requirement for the specific project.

## Germany: Blended scoring system

The Assessment System for Sustainable Building (Bewertungssystem Nachhaltiges Bauen, BNB) was made mandatory in 2011 for all federal-government construction projects by the Federal Ministry of the Interior, Building and Community.[9] This system consists of five main criteria groups (see Appendix figure 10), which are weighted to produce an overall score for federal buildings covered by these regulations. The silver standard is the minimum for most projects to be allowed to proceed, while the gold standard is the more ambitious target reserved for office, educational and laboratory buildings and outdoor facilities. Global warming potential is included in the Ecological Quality category and makes up 3.75% of the total score.

### Appendix figure 10 – BNB assessment system categories and scale




Source: German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), Assessment System for Sustainable Building: Administration Buildings, 2014, https://www.bnb-nachhaltigesbauen.de/fileadmin/publikationen/assessment_system_bnb.pdf.

## France: GWP limit

In 2020, France passed legislation known as RE2020, which set maximum emissions thresholds per square meter for housing, schools and offices beginning in 2022, applicable to buildings in both the public and private sectors. These thresholds are scheduled to be lowered in 2025 and 2028 (see Appendix figure 11).

### Appendix figure 11 – RE2020 GWP limits

| Building use | Maximum value (kg $CO_2$/ $m^2$) | | | |
|---|---|---|---|---|
| | 2022 - 2024 | 2025 - 2027 | 2028 - 2030 | 2031 onward |
| Detached or attached houses | 640 | 530 | 475 | 415 |
| Collective housing | 740 | 650 | 582 | 490 |
| Offices | 980 | 810 | 710 | 600 |
| Primary or secondary education | 900 | 770 | 680 | 590 |

Source: Legifrance - The Public Service for the Dissemination of the Law, Code of Construction and Housing, Appendix to article R172-4 Chapter 2, n.d., http://rt-re-batiment.developpement-durable.gouv.fr/.

### United States: GWP limit

In 2022, the United States General Services Administration, a federal agency, issued new standards for the concrete and asphalt used in construction, modernization and paving projects that it awards. The new standards set GWP concrete limits 20% below the limits recommended by the non-profit New Buildings Institute, which are based on the 75th percentile of EPDs collected by the EC3 database[10] and require contractors to provide EPDs when available.

In the United States, a number of states have drafted or passed "Buy Clean" policies that limit GWP on products purchased through public procurement. Below are a few examples. It is worth noting that there are additional existing and emerging policies throughout the United States beyond these examples.

The Buy Clean California Act (BCCA), passed in 2017, requires the Department of General Services (DGS) in consultation with the California Air Resources Board (CARB) to set maximum allowed levels of embodied carbon emissions for some categories of construction materials. Currently concrete is not among these categories but there is a draft proposal to add concrete products to the mix. The methodology used to set the maximum acceptable global warming potential limits could foreshadow possible similar limits for concrete products. Limits are set across four categories of steel, indicating multiple concrete baselines (by strength or application) are likely. Beginning on 1 January 2025 and every subsequent three years, DGS will review the maximum acceptable GWP for each material and may adjust the limit downward to reflect industry improvements. The BCCA legislation prohibits DGS from adjusting the limit upward. The EPDs submitted for compliance must be facility-specific manufacturer declarations and independently verified in accordance with ISO 14025.[11]

Similarly, as of 1 January 2024, the Buy Clean Colorado Act will require the Office of the State Architect and Department of Transportation to set GWP limits on concrete and other building materials for state funded building and transportation projects. Contractors will not be able to use materials on the project that have not been validated through an EPD. However, if a product or material meets the maximum acceptable GWP but is not reasonably priced or available at the time of design or construction, the agency may waive the requirements.

## III. Providing economic incentives

### Netherlands: Company performance score

In the Netherlands, contracting authorities, such as the Directorate-General for Public Works and Water Management (Rijkswaterstaat) select the bidder with the lowest price, including discounts based on the ambition level of the bidders to achieve carbon emissions reductions (with the levels based on the $CO_2$ Performance Ladder) and from a low score in the environmental cost indicator (ECI or MKI, described above in Appendix section A II). If the contractor later fails to reach the promised ECI level, a penalty of 1.5 times the awarded discount is recommended.

The $CO_2$ Performance Ladder is an instrument used as both a $CO_2$ management system and a green procurement instrument. By implementing the management system, the ladder helps organizations reduce carbon emissions internally and in projects and their supply chain. With a certificate on the ladder, organizations can receive an award advantage in tenders. Levels 1-3 concern carbon management and reduction targets within the builder's own organization (scope 1 and 2 emissions), while levels 4 and 5 focus on carbon reductions within the supply chain. At all levels, four perspectives are applied: insight, reduction, communication and innovation. A percentage reduction of the submission price is applied based on the bidder's level on the $CO_2$ Performance Ladder.[12]

### Sweden: Carbon abatement reward

The Swedish Transport Administration (STA) awards a bonus of 1,000 SEK/t$CO_2$e (~€100/t$CO_2$e) for each tonne of $CO_2$ equivalent avoided by a contractor beyond the emissions reduction requirement, usually up to 1% of the total contract value. A penalty twice the level of the bonus is imposed if the emissions reduction requirement is not met.

### United States: Product and technology incentives

In the United States, a proposed amendment to the Buy Clean California Act, if passed, would require awarding authorities to apply a fictitious discount to bids with a GWP for concrete at least 10% below the average qualified bid. Bids with the lowest GWP would be eligible for the largest discounts, capped at 5% of the cost of concrete. Additional fictitious discounts of up to 3% of the cost of concrete are proposed for bids for concrete produced using qualifying breakthrough technologies, which would presumably include CCUS. Penalties are proposed if the bidder fails to deliver the materials at the embodied carbon levels proposed in the bid. The state of New Jersey has drafted similar legislation that would, if passed, provide similar incentives in the form of tax credits.

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