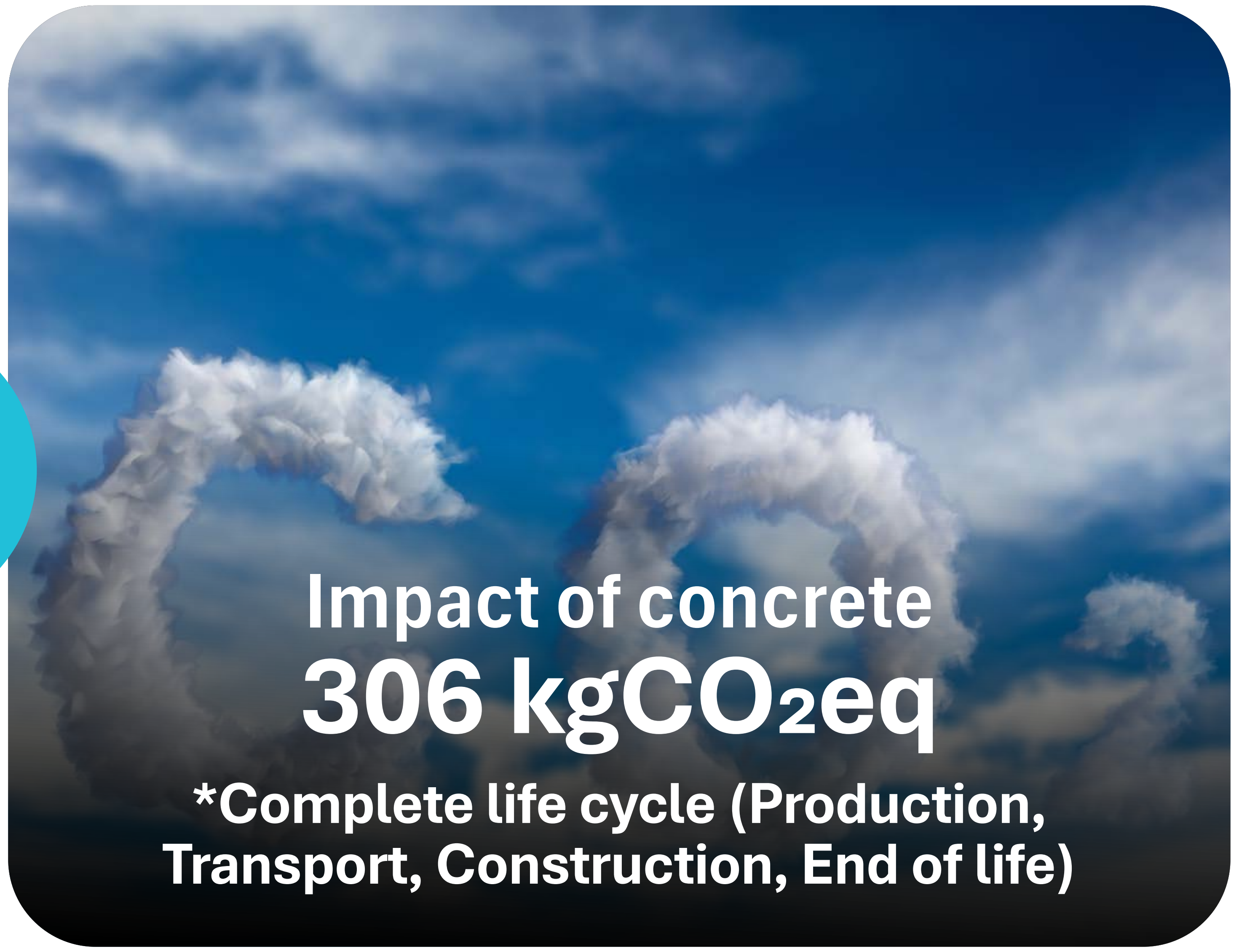
LIVING LAB
CIRCULAIR BETON

The Concrete Life Cycle

The impact of a reference concrete in Belgium

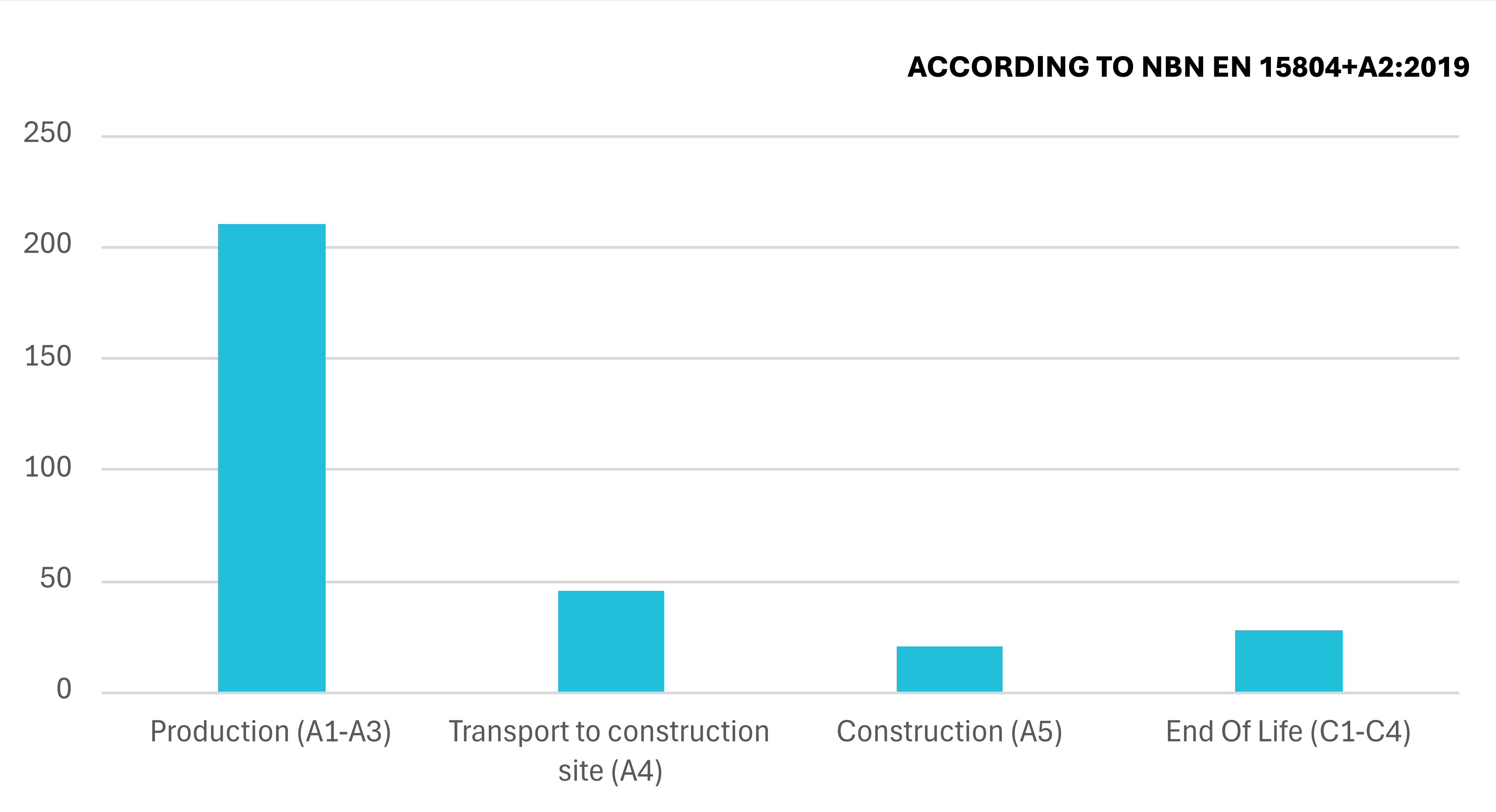
Concrete C25/30 EE2 CEM IIIA - 330 kg Cement /m^3



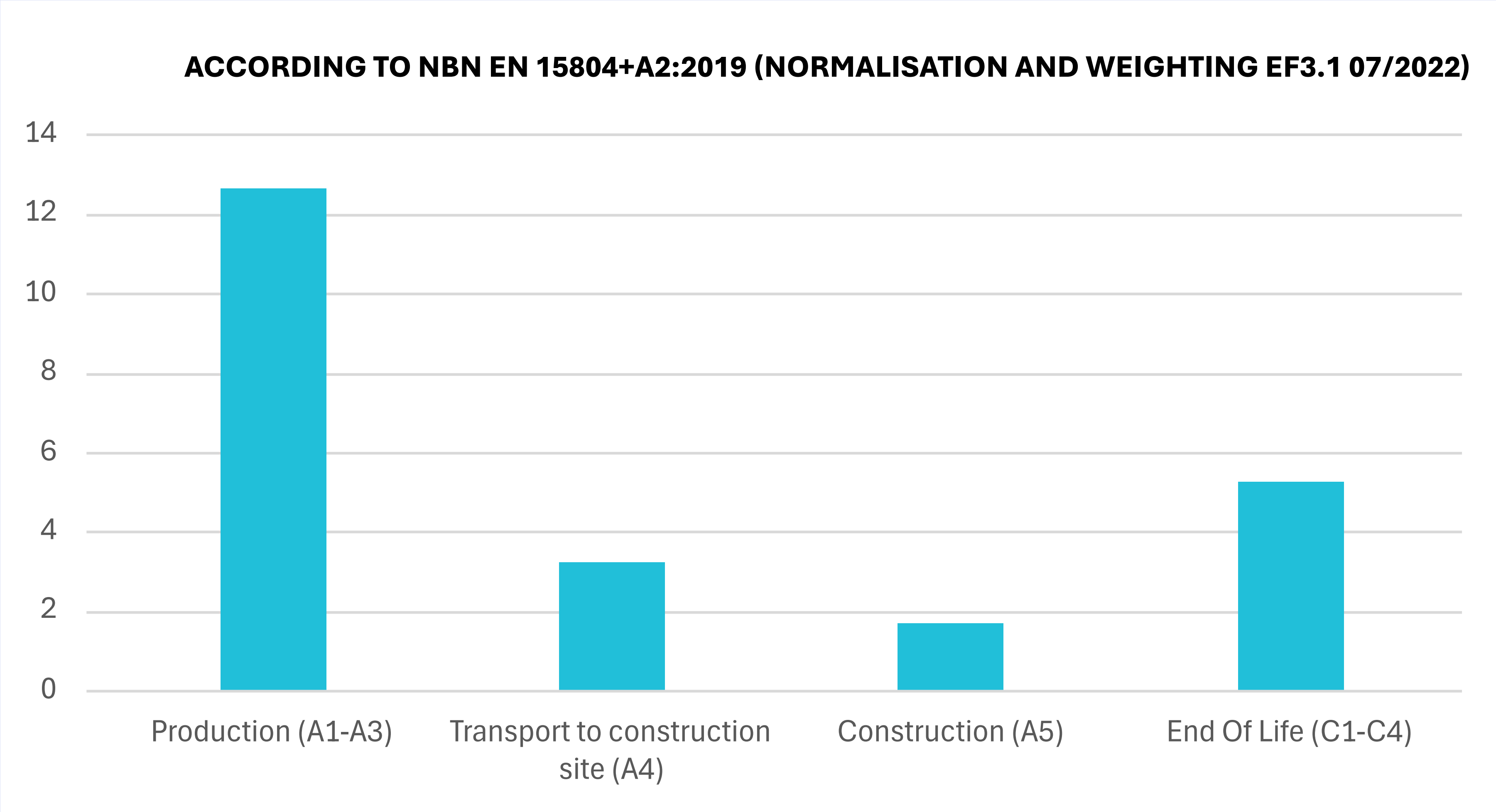
The impact of a reference concrete in Belgium

Concrete C25/30 EE2 CEM IIIA - 330 kg Cement /m^3

Concrete C25/30 EE2 CEM IIIA - **$kgCO_2eq/m^3$**



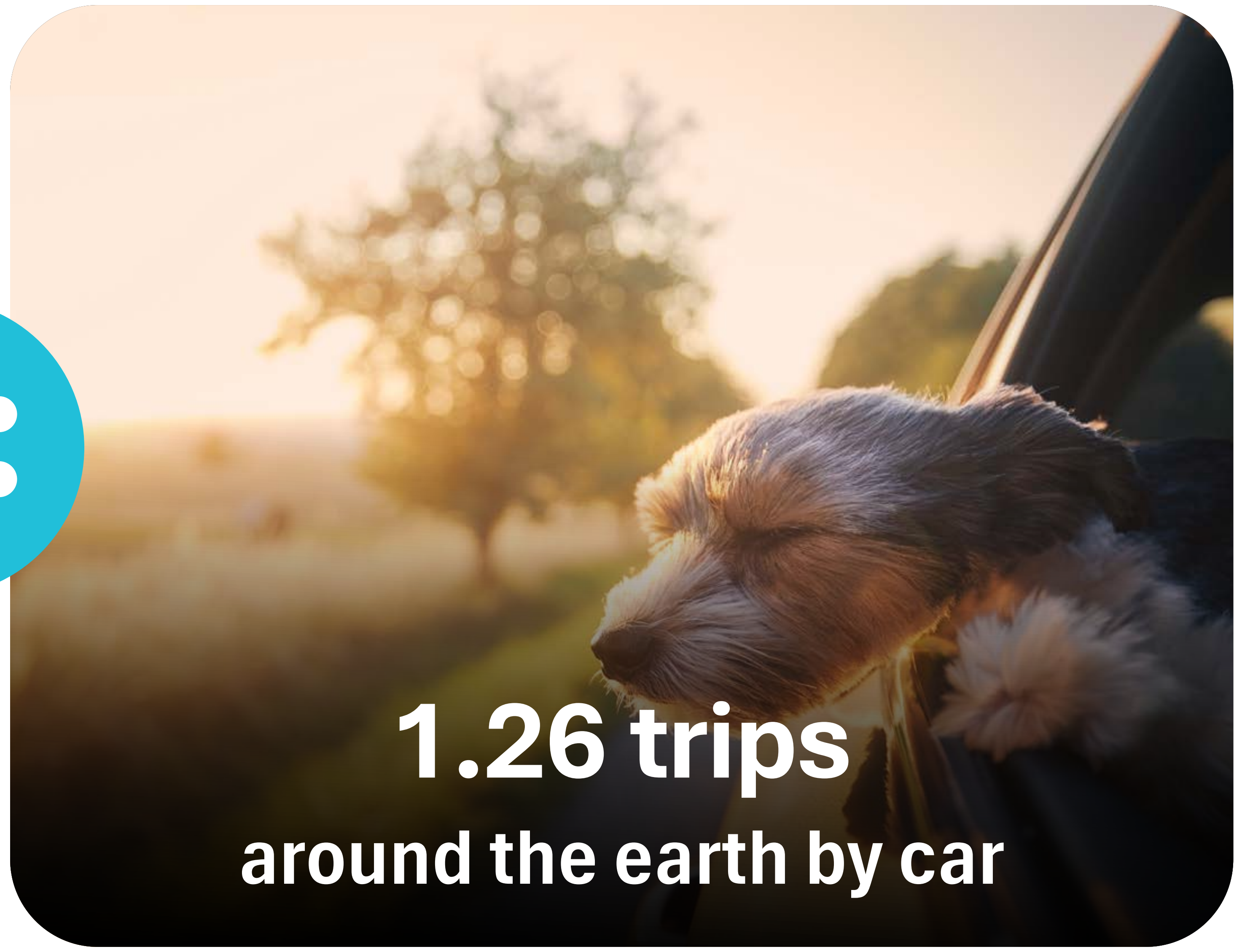
Concrete C25/30 EE2 CEM IIIA - **mPt /m^3**



ANALYSE

- At concrete level : In the context of climate change ($kgCO_2eq$), the focus is on production and transport to the construction site stages. In the context of a multi-indicator approach (mPt) considering multiple environmental issues, the focus is on production, transport to the construction site and EOL stages. In order to avoid pollution transfers, it is necessary to consider both approaches.
- Impact is unevenly distributed across life cycle stages, but each concrete life cycle actor can play a rôle to reduce concrete overall impact.
- Some concrete life cycle actor can have a limited impact on CO_2eq emissions but a more important influence on others environmental issues.

Concrete building in Belgium



(Reinforced concrete slabs and fired clay hollow brick walls)
*Reference concrete used in Belgium : C25/30 EE2 CEM IIIA

ANALYSE

- High impact of concrete ➔ The use of concrete must be carefully considered.
- Limitation of quantities ➔ Limitation of impact

The concrete life cycle

Raw material supply (A1)

- Cement producer
- Sand /Gravel producer

Transport & Production (A2-A3)

- Concrete producer
- Raw material carrier

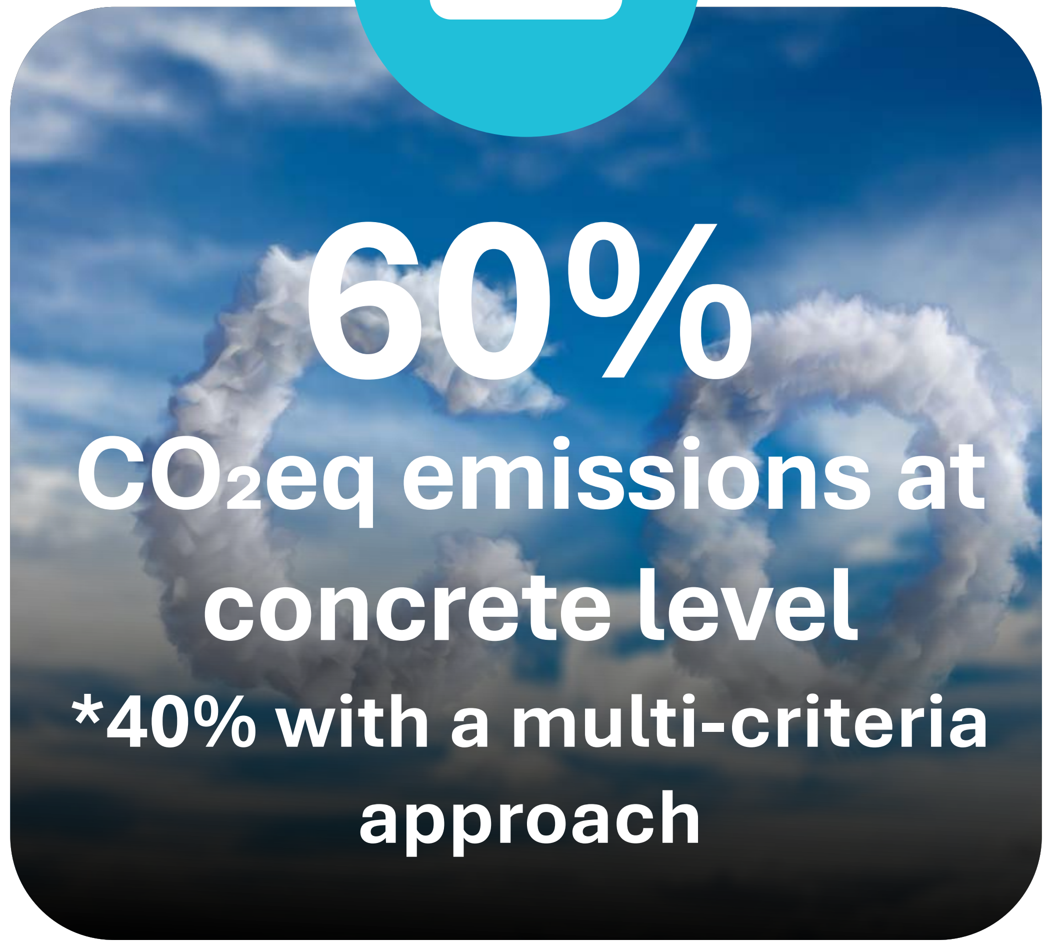
End Of Life (C1-C4)

- Construction company
- Demolition company
- Architect
- Engineering office

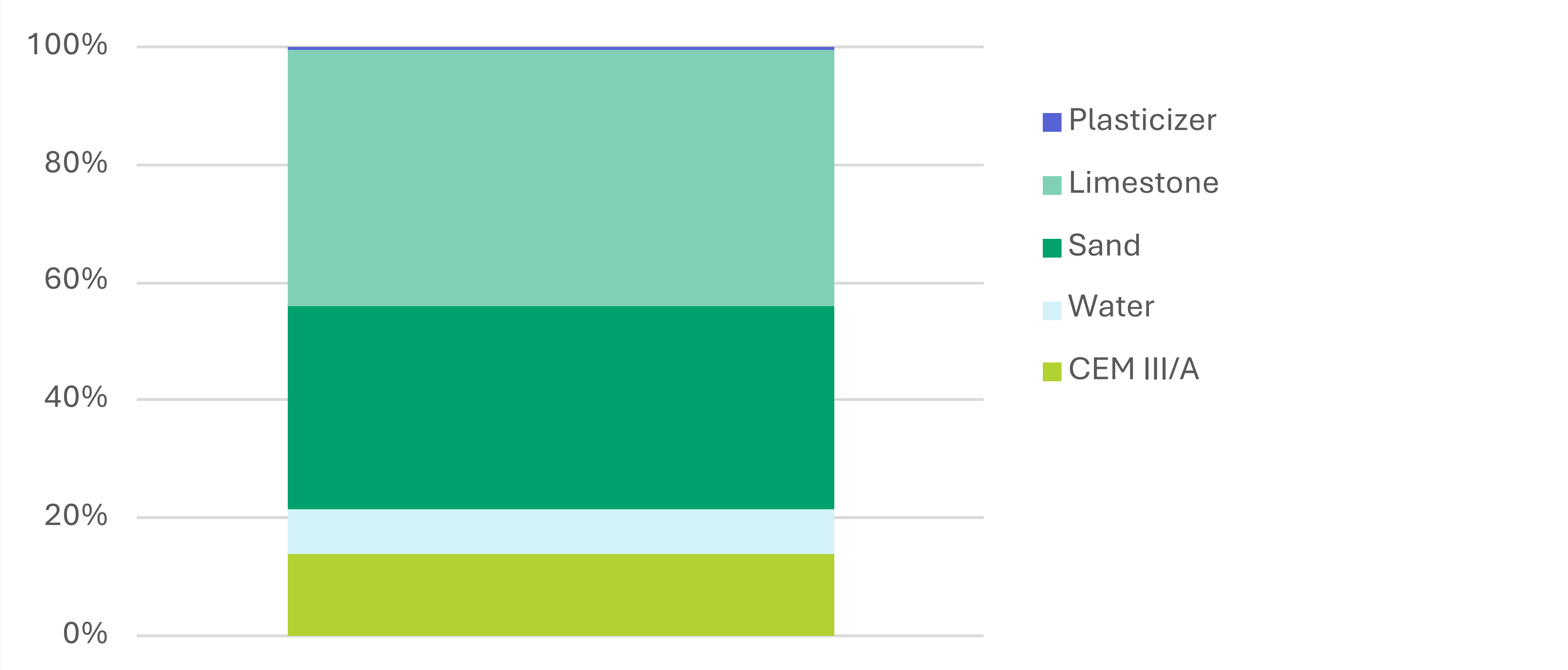
Transport & Construction (A4-A5)

- Construction company
- Engineering office

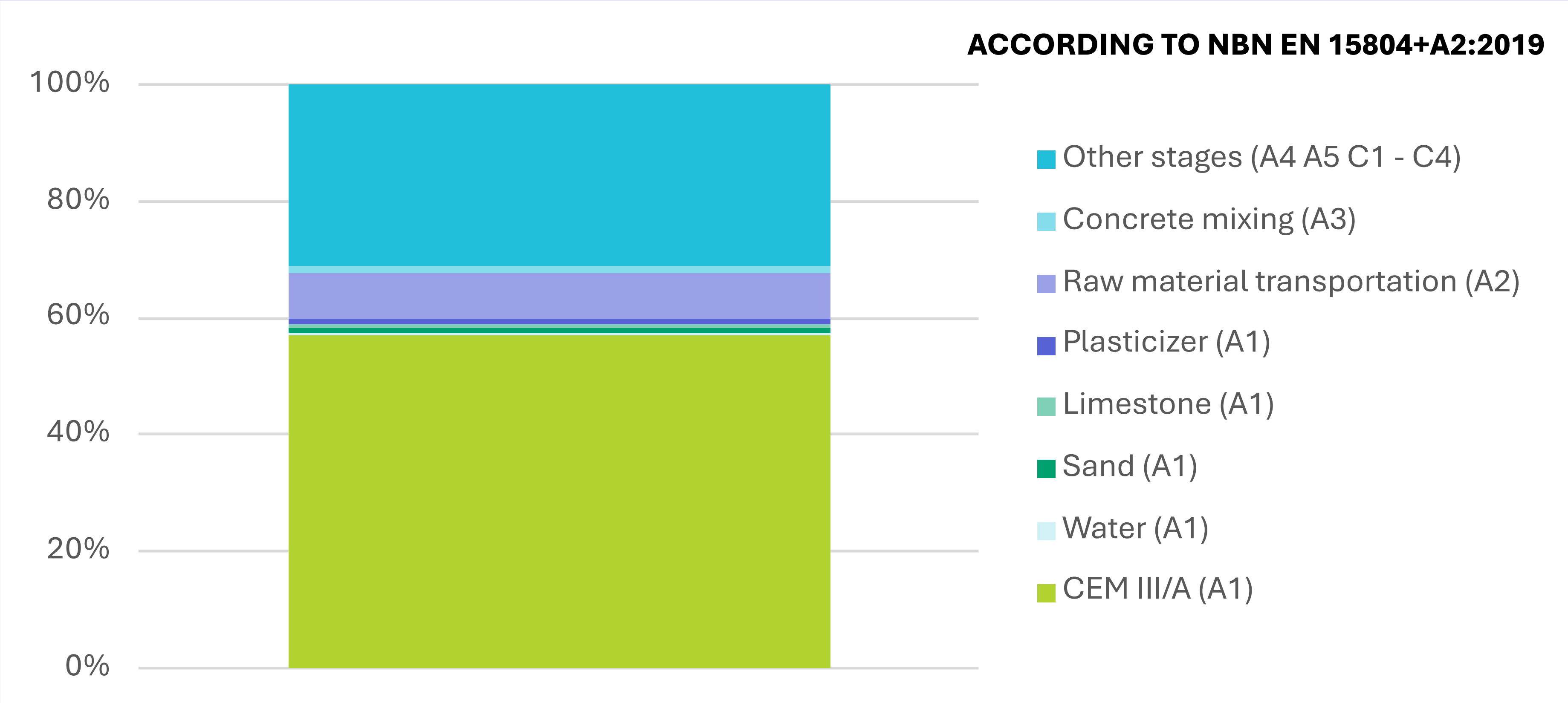
C25/30 EE2, focus on production impact (A1-A3)



Materials in concrete C25/30 EE2 – **Mass %**



Concrete C25/30 EE2 - **CO_2eq Impact %** (Cradle to Grave)



The cement represents 15% of the concrete in mass but is responsible for most CO_2eq emissions (60%) and 40% with a multi-criteria approach.

➔ Reducing the impact of cement is a priority. However, further optimizations are possible.

The concrete life cycle

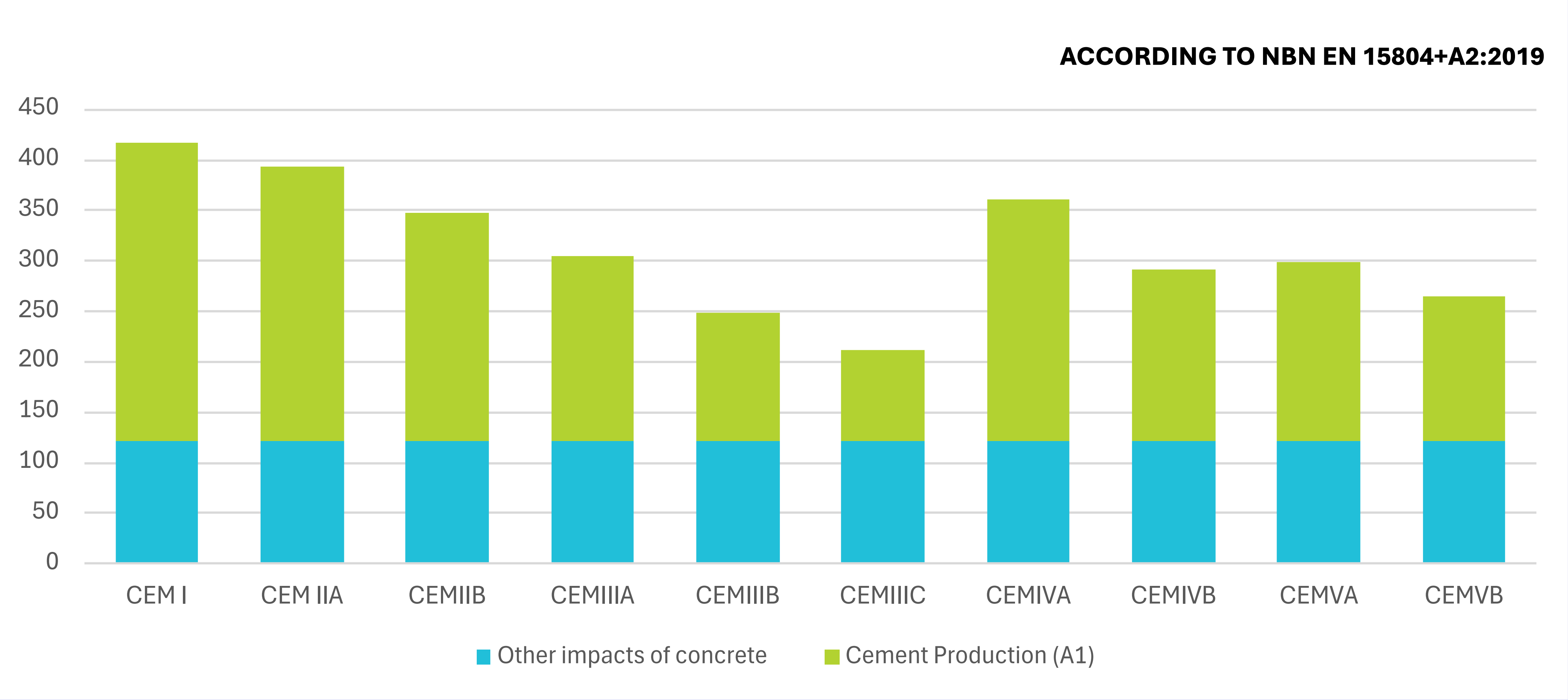
Raw material supply (A1) | Transport & Production (A2-A3) | Transport & Construction (A4-A5) | End Of Life (C1-C4)

Cement in concrete (Generic data)

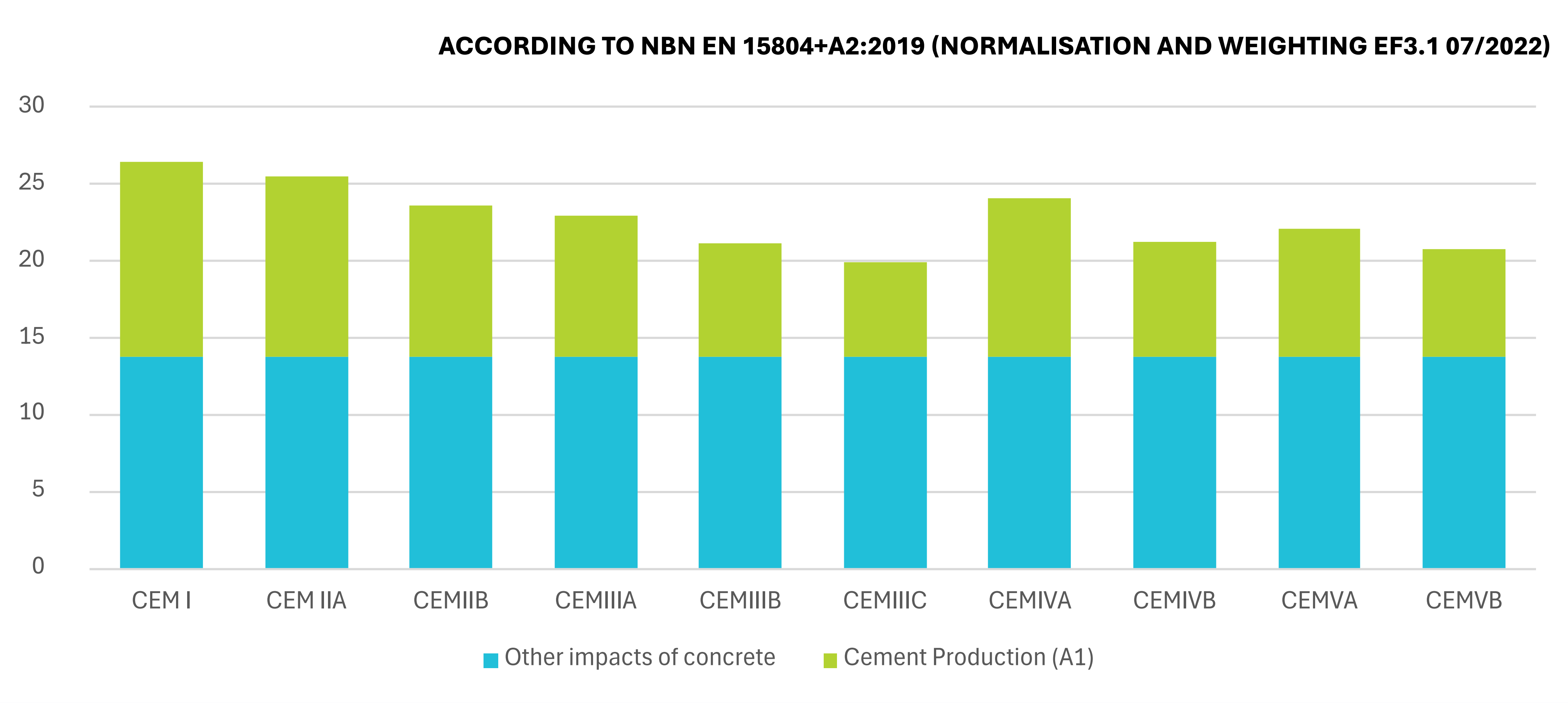
Possible gain by adapting the type of cement in the reference concrete:

- Reduction by up to 50% of CO_2eq emissions by modifying the type of cement and thus limiting the quantity of clinker. Clinker is replaced by other binders : Blast Furnace Slag (CEM III) or a mix of fly ash, Limestone, Blast Furnace Slag, ... (for CEM II, CEM V).
- Reduction by up to 25% with a multi-indicator approach.

Concrete C25/30 EE2 - **$kgCO_2eq/m^3$** (Cradle to Grave)



Concrete C25/30 EE2 - **mPt/m^3** (Cradle to Grave)



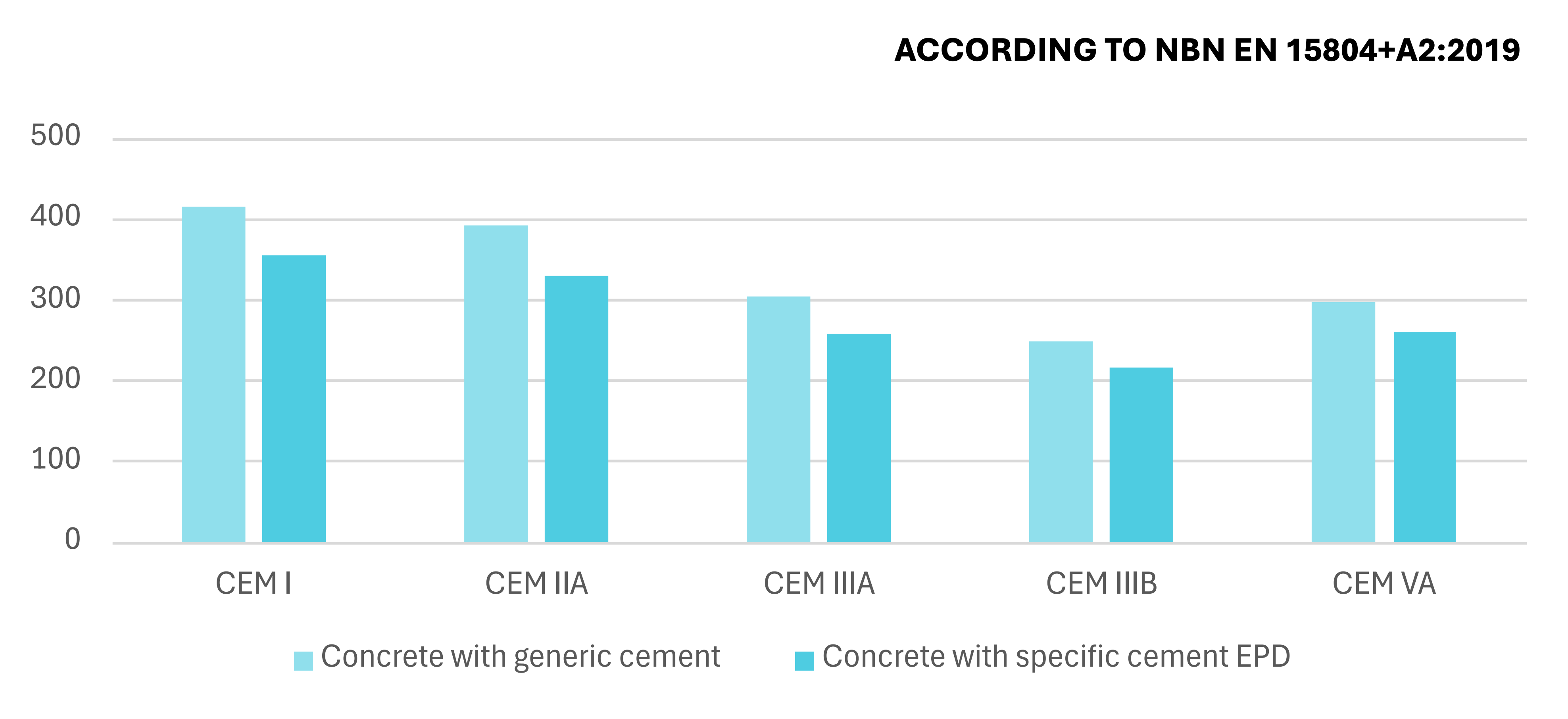
Cement has a relatively high impact on CO_2eq emissions and a more limited one with a multi-indicator approach. Therefore, it is relevant to go beyond cement optimisation to tackle other environmental issues besi-des climate change.

Limitations :

- Need to keep in mind technical requirements and implementation rules (Consequences on construction site - Drying time, phasing ...).
- Impacts are based on generic data. Give priority to specific data by using cement or concrete EPDs (Environmental Product Declaration). For a given cement type, impact can vary according to the factory.
- The limited availability of blast furnace slag and fly ash implies the use of new generation of cement (with calcined clay, ...).

Specific Cement in concrete (Using EPDs)

Concrete C25/30 EE2 - **$kgCO_2eq/m^3$** (Cradle to Grave)



The use of data from cement-specific EPDs (Environmental Product Declaration) for assessing the impact of concrete can potentially lead to a reduction in impact (up to **15% in this specific case**).

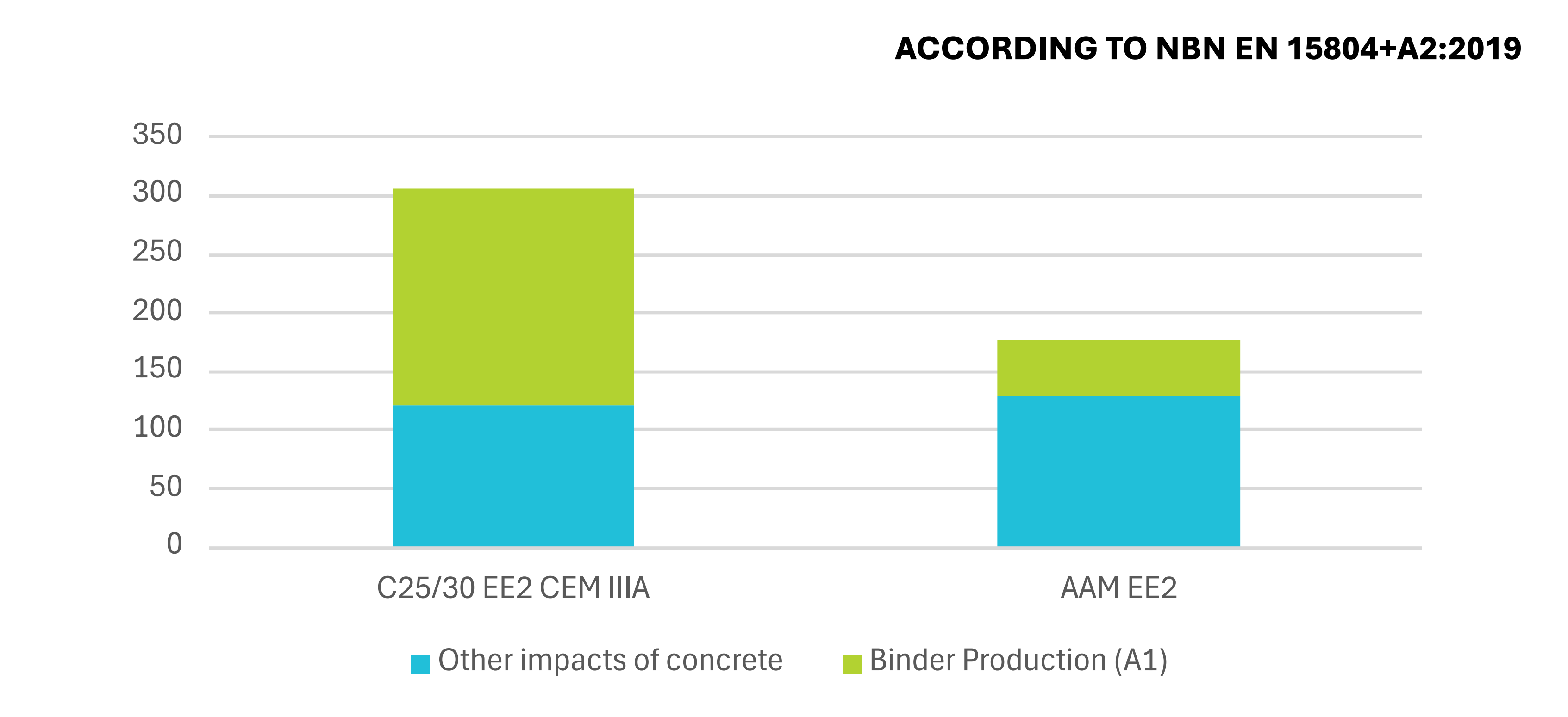
Looking at cement EPDs allows to take into account specific production process (Altenative fuels, New binders, ...) and to eventually reduce the impact of concrete.

Points of attention to compare **cement** EPDs :

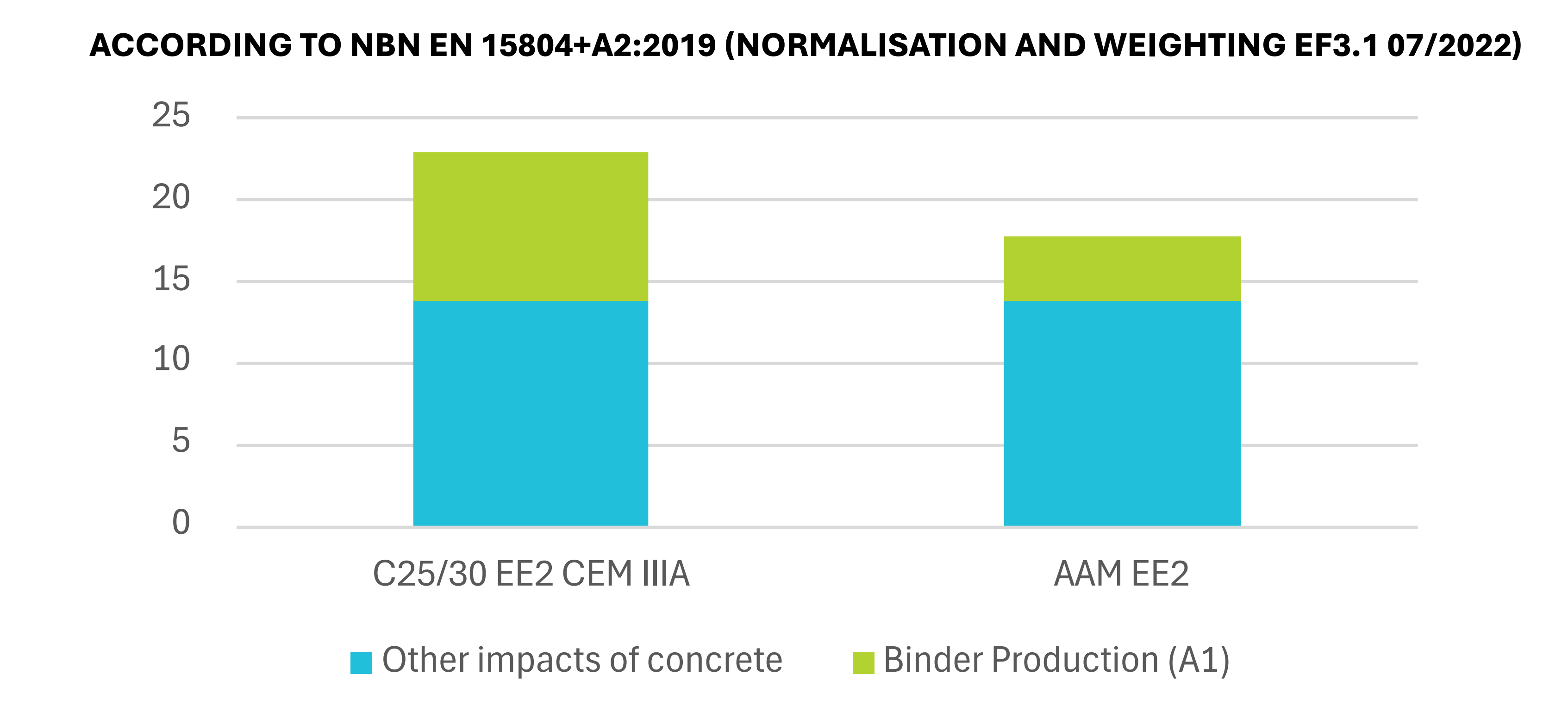
- EPDs must come from the same EPD database. This ensures that the life cycle scenarios are comparable.
- Based on the same standard **NBN EN 15804+A2:2019.**
- Comparison at **concrete level** with identical technical performances (Same functional unit).

With Other Binders - Alcali Activated Materials (AAM)

Concrete and AAM - **kgCO₂e/m³** (Cradle to Grave)



Concrete and AAM - **mPt/m³** (Cradle to Grave)



AAM EE2 vs C25/30 EE2 CEM IIIA with comparable performances :

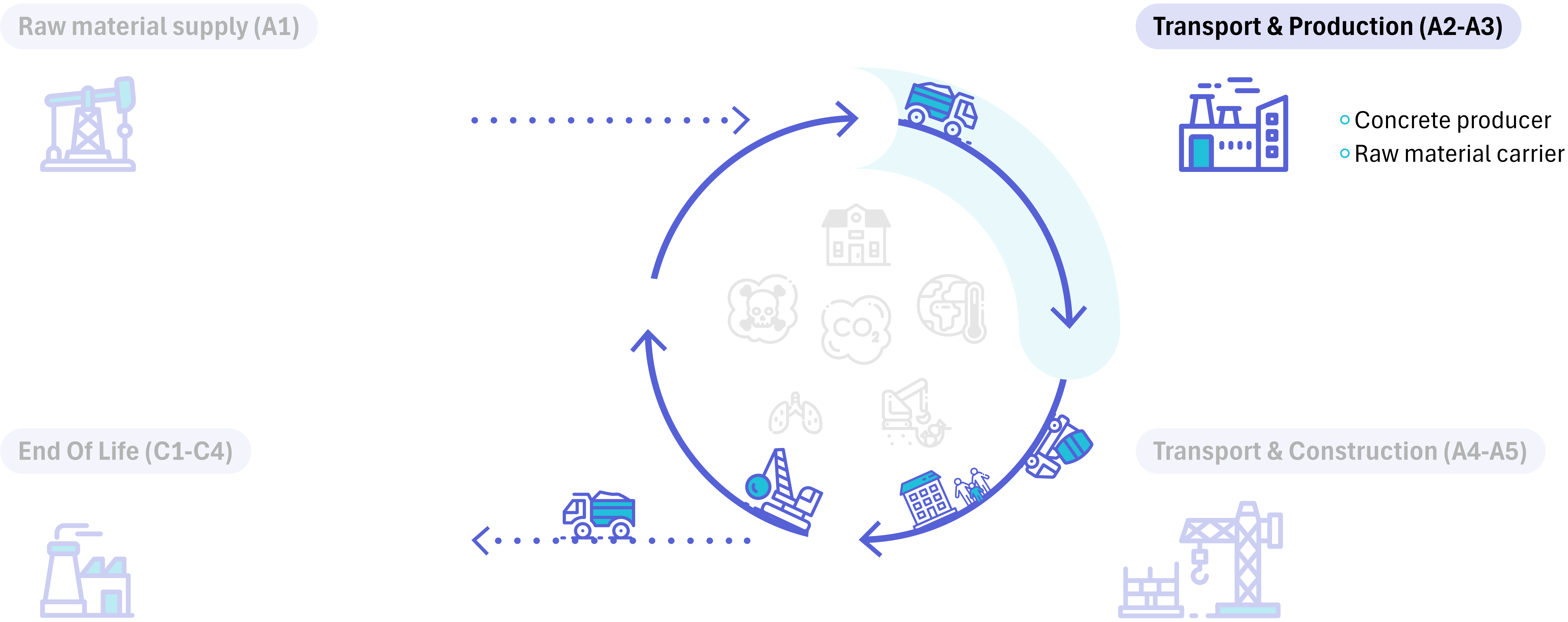
Alcali Activated Materials (AAM) also called « Geopolymer » can **significantly reduce the environmental impact in the concrete mix.**
No clinker is used in this AAM. Cement is replaced by the combination of an activator and a precursor.

Limitations :

- The impact calculated concerns a **specific AAM**. Compositions of AAM can largely change and have big implications on their environmental impacts.
- There is a **risk of pollution transfer** from an environmental problematic to another (Mainly concerning the activators). Therefore, it is necessary to assess AAM at multi-indicator level and not only focusing on climate change.

The concrete life cycle

Raw material supply (A1) | **Transport & Production (A2-A3)** | Transport & Construction (A4-A5) | End Of Life (C1-C4)

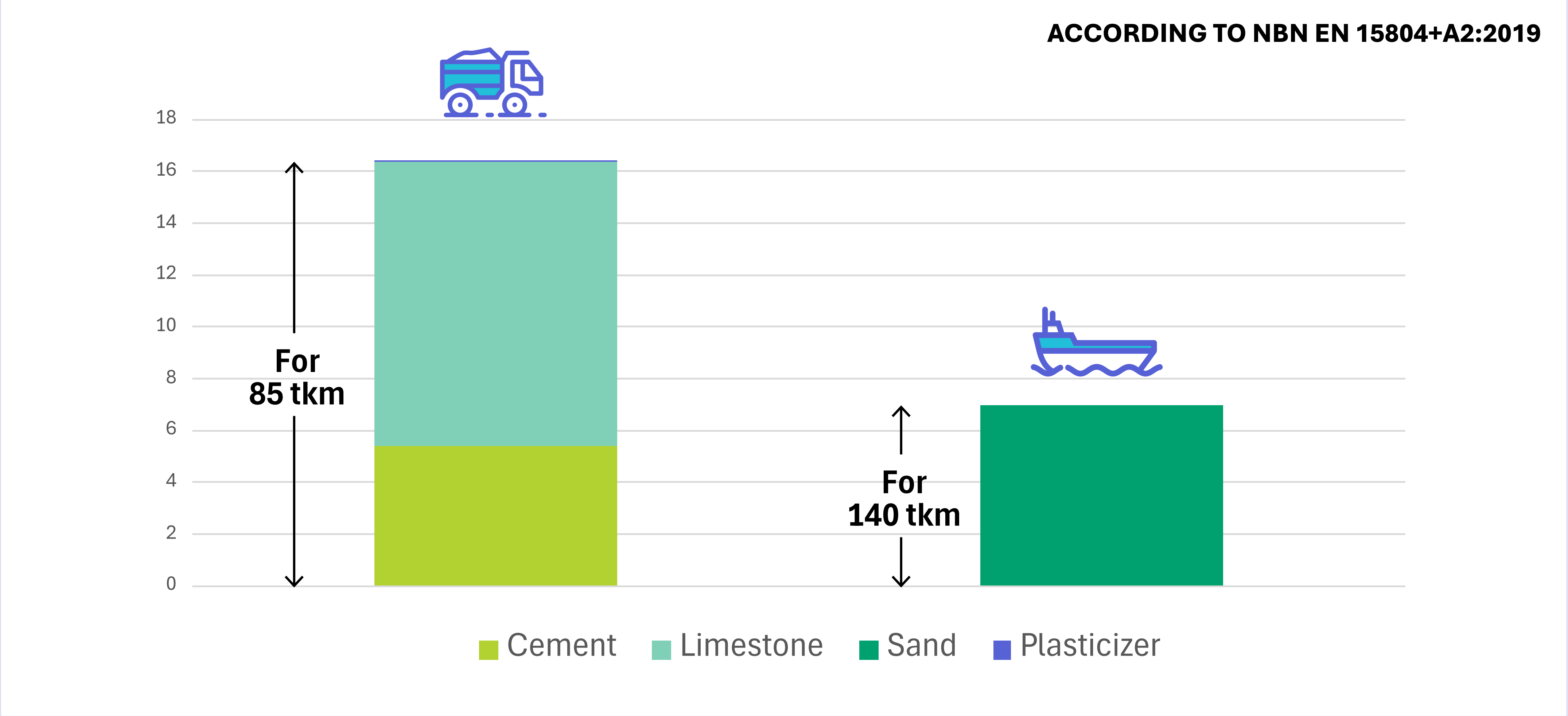


Transport of raw materials (A2)

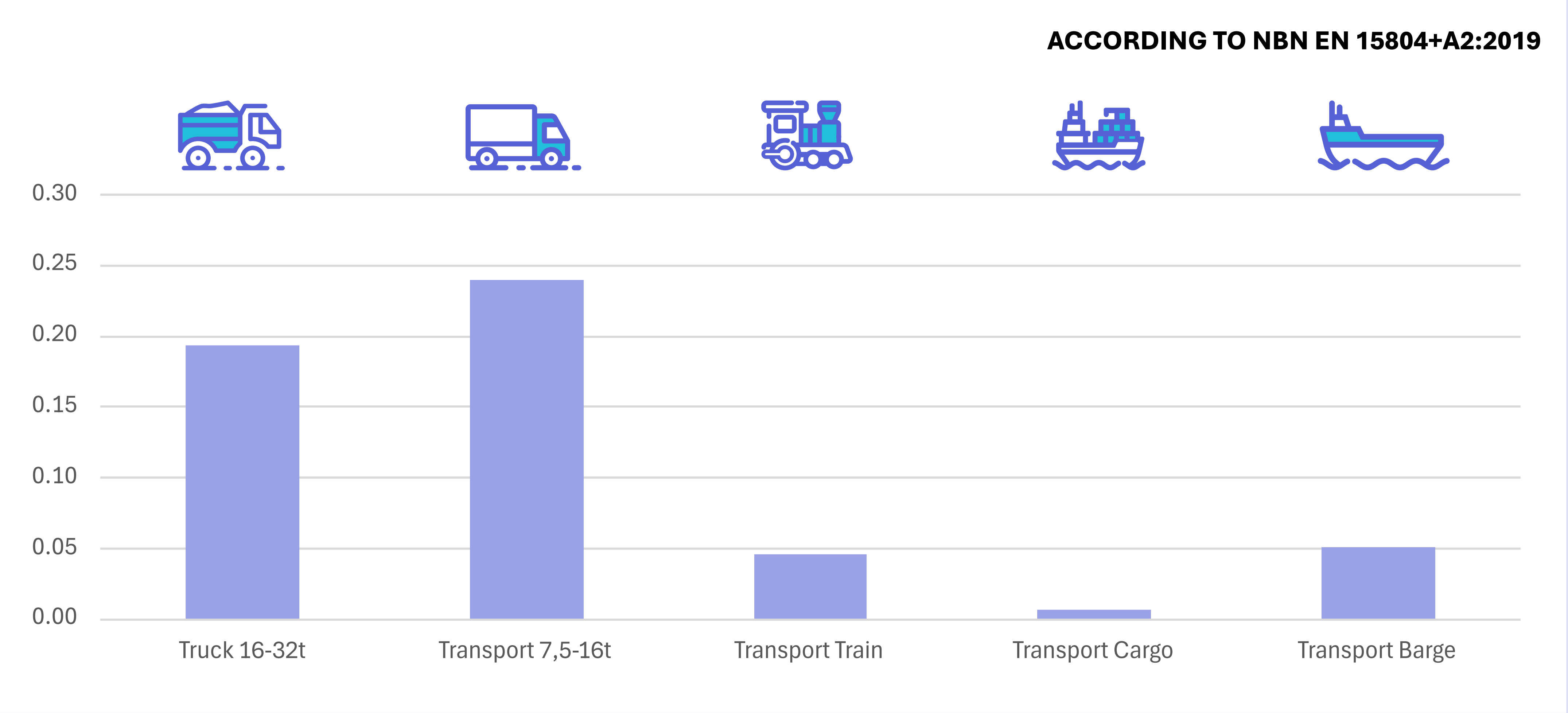
Impact of raw material transportation

The impact of raw material transportation accounts for approximately 10% of the concrete impact (in terms of climate change and multi-indicator approach).

Impact of Raw Material Transportation for 1m³ of Concrete - **kgCO2eq**



Impact by transportation type - **kgCO₂eq/tkm**



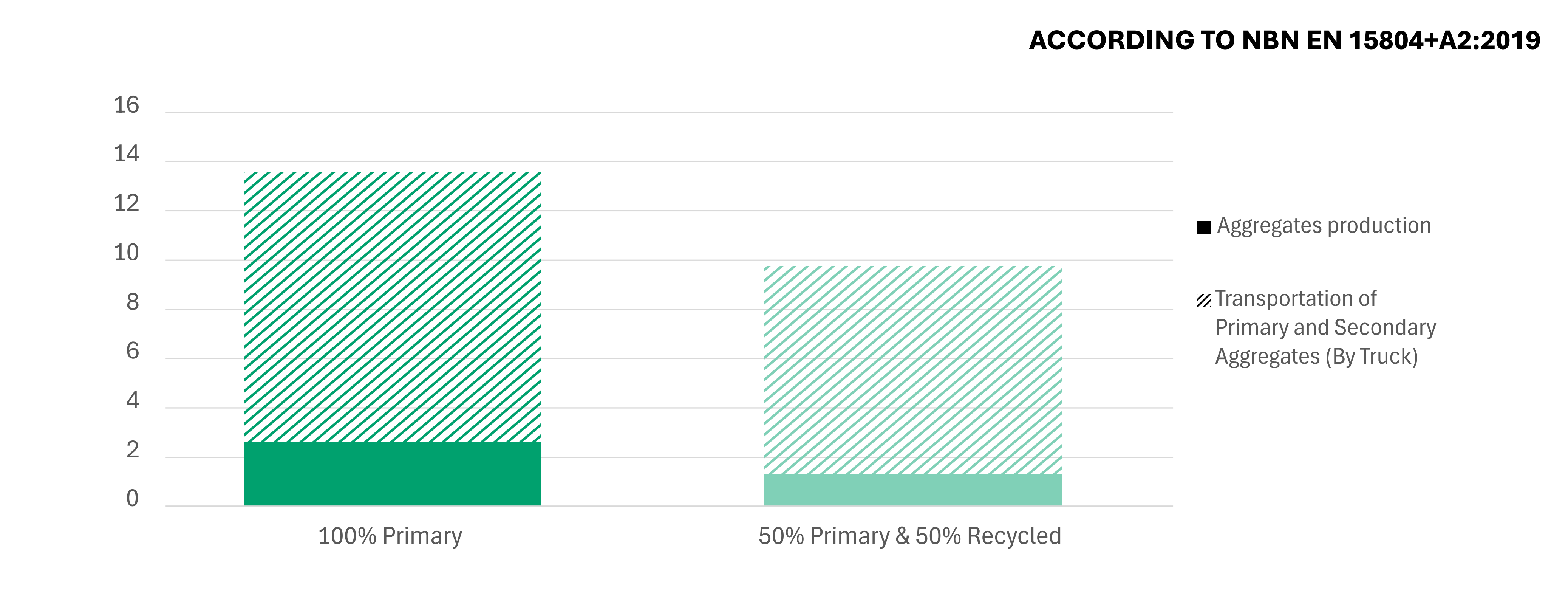
Possible gain by adapting the type of transport and reducing the distan-ces in the reference concrete :

- Favor barge over Truck transportation even if the trip in barge is longer. (CO_2 impact of barge transportation is 4 times smaller than CO_2 impact of Truck transportation for the same distance and load).
- If truck transportation cannot be avoided, the distance of travel should be minimized.
- The transport must be as full as possible.

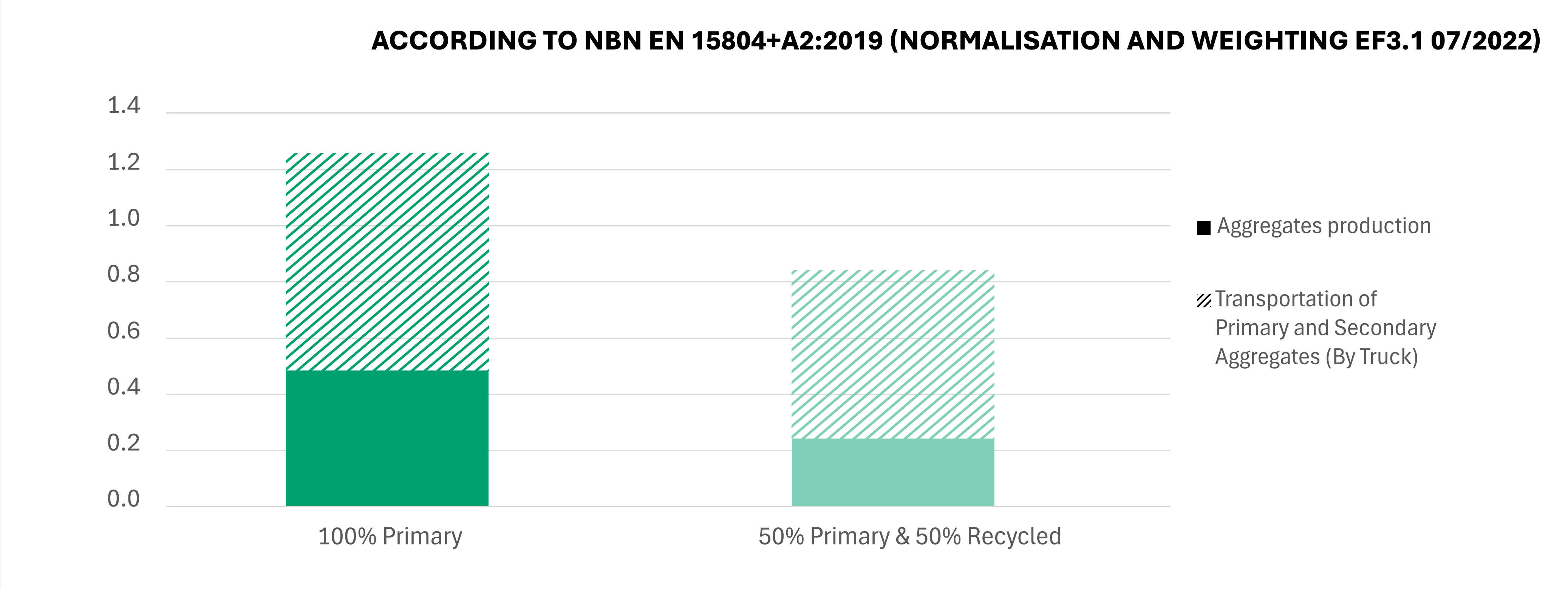
Train Transportation could also be an alternative to Truck transportation.

Transport of recycled granulates (A2)

Aggregates in concrete C25/30 EE2 (**$kgCO_2e/m^3$**)



Aggregates in concrete C25/30 EE2 - **mPt/m^3**



In a concrete, using 50% of recycled aggregates allows to reduce the impact of **aggregates production** by up to 50%.

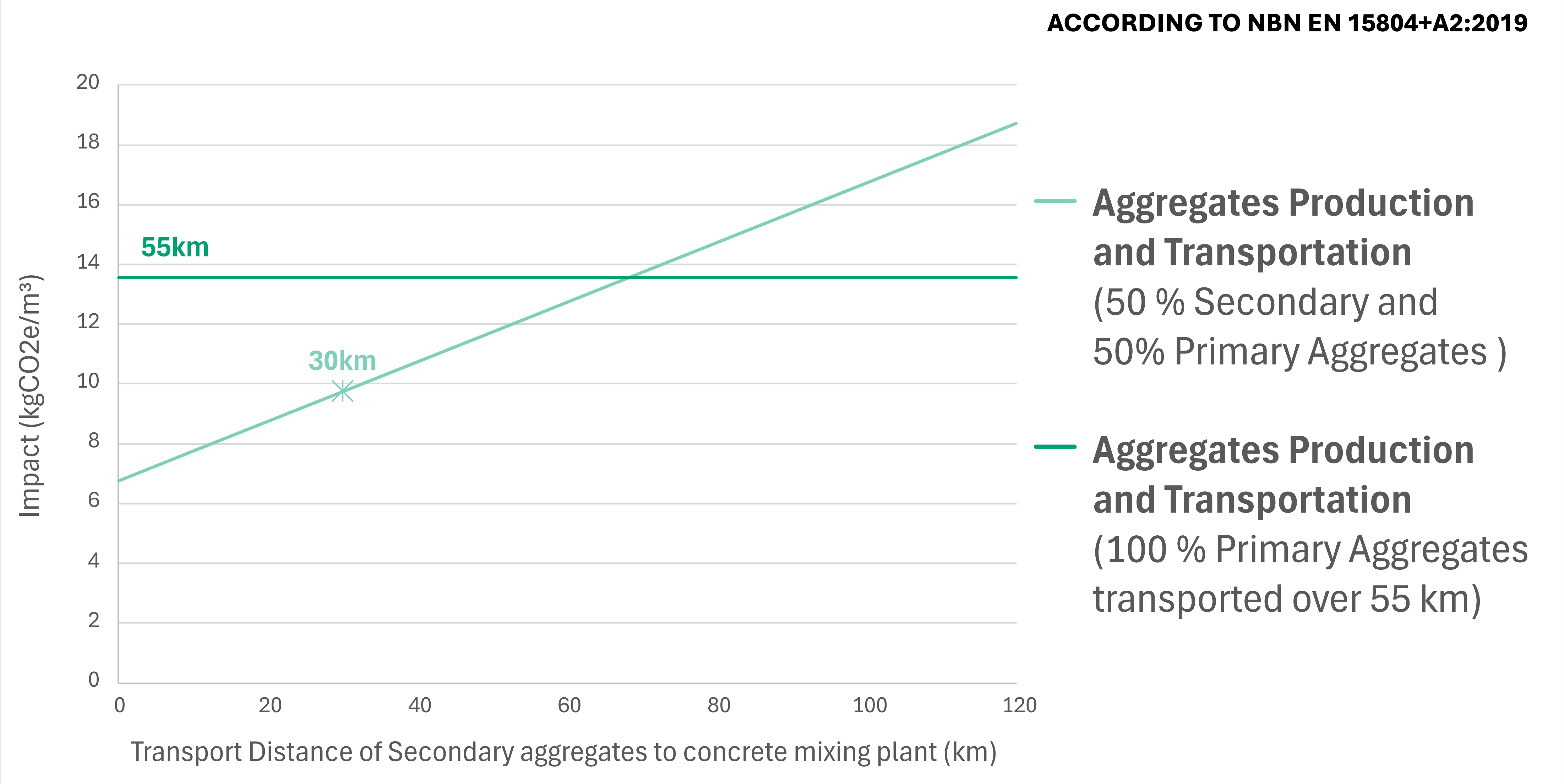
Using secondary aggregates allows to :

- Reduce the need for new aggregates quarries.
- Save natural resources (aggregates). Please note, however, that the Local depletion of aggregates is not taken into account in LCA.
- Reduce inert waste (saturation of the road sector).
- Reduce transport-related nuisances.

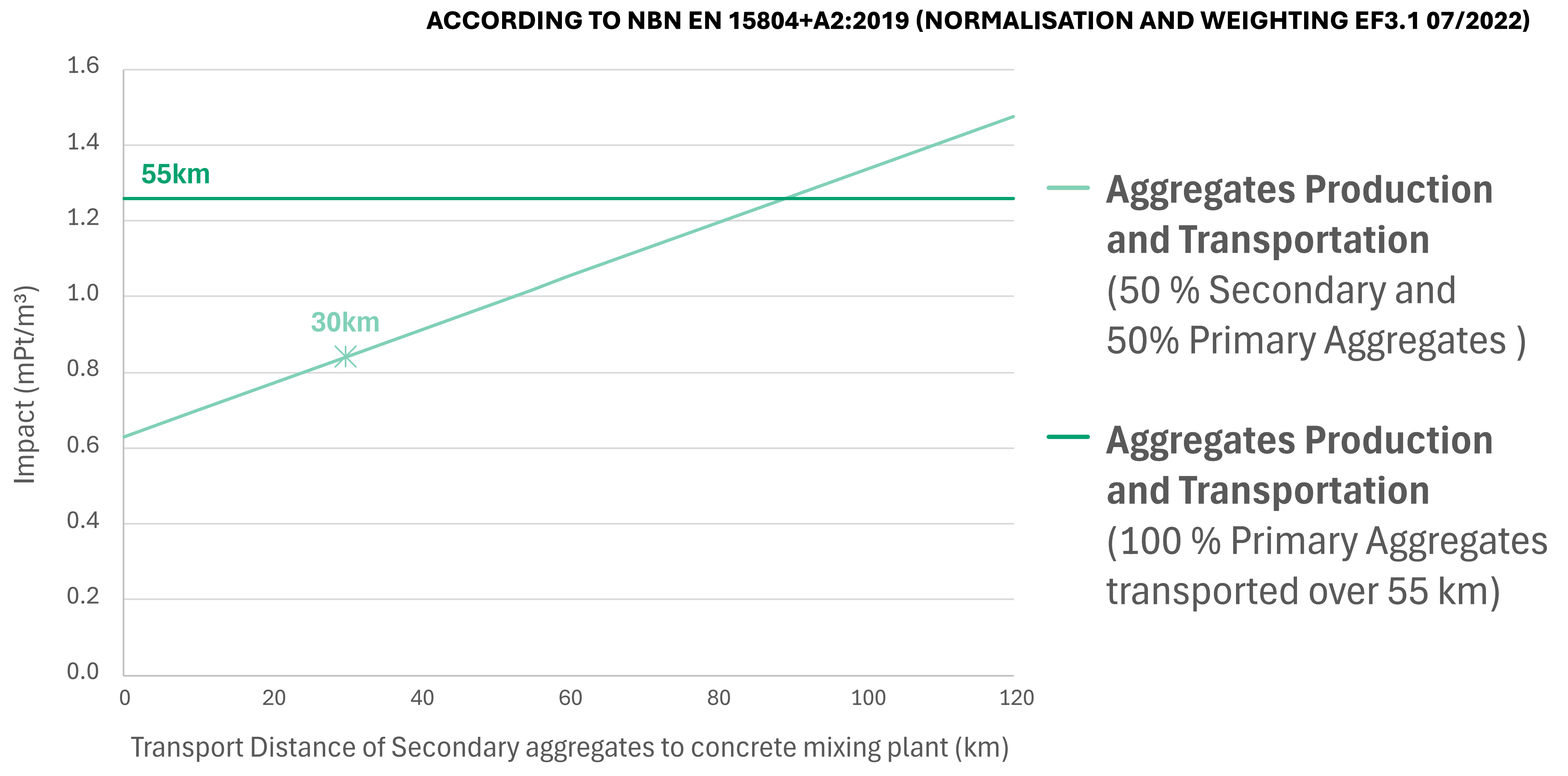
Limitations :

- Using recycled agregates has a limited impact on the LCA-score. The impact of aggregates is limited compared to other concrete components.
- Check impact of recycled aggregates on concrete performances. If more cement is needed to reach the given performances, the choice to use recycled aggregates should be reconsidered.

Aggregates in concrete C25/30 EE2 (**$kgCO_2e/m^3$**)



Aggregates in concrete C25/30 EE2 - **mPt/m^3**



To retain the benefits of using recycled aggregates, the truck transport of the recycled aggregates **cannot exceed the transport distance of the primary aggregates by more than 35km (and 13 km with a climate change approach).**

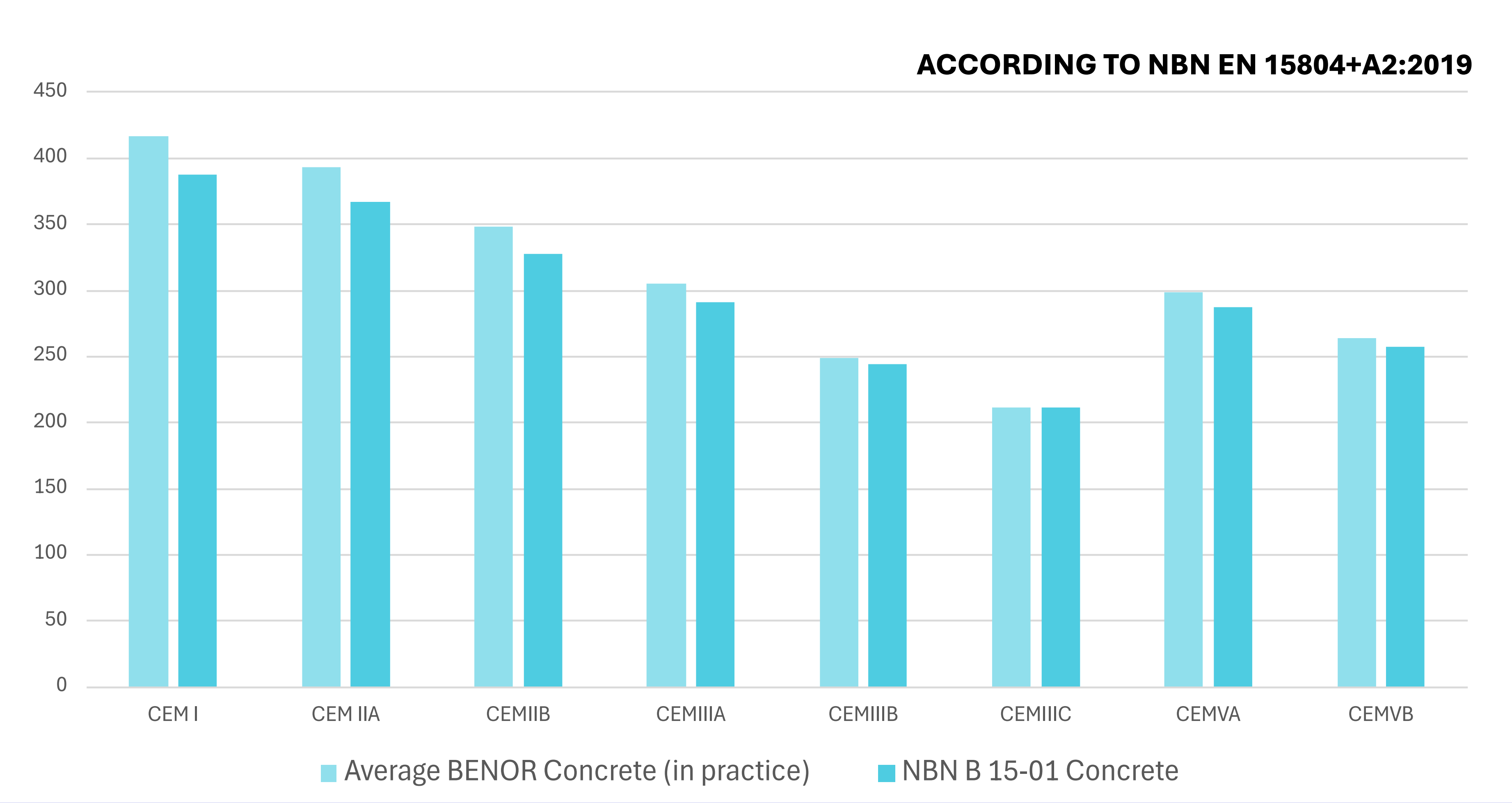
Cement content (A3)

Reduce Cement content:

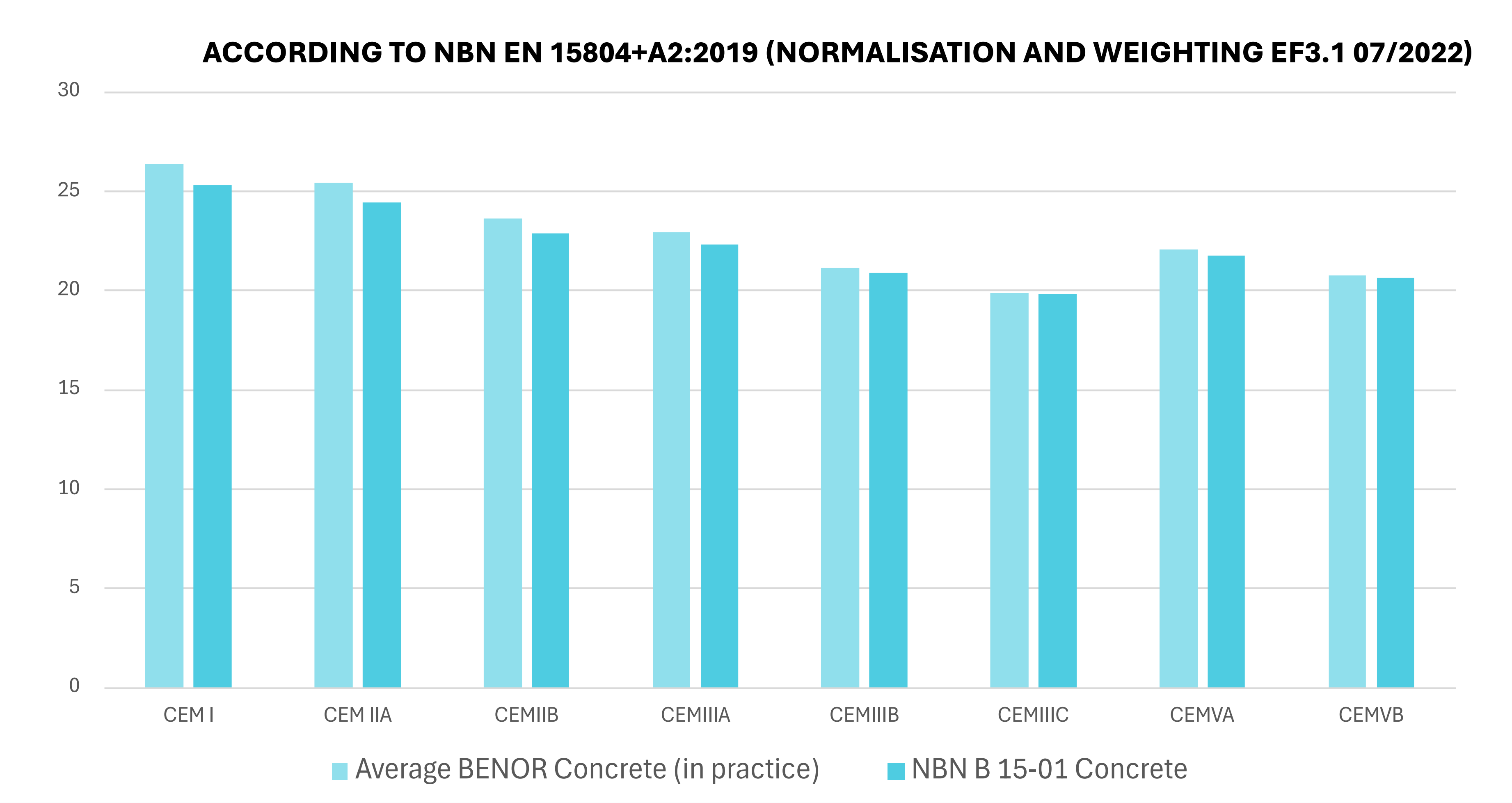
Reducing the cement content to the minimal cement content needed would according to the chosen type of cement reduce CO_2eq emissions impact **by up to 7% (when CEM I is used)** and with a multi-indicators approach by up to 4%.

The concrete life cycle

C25/30 EE2 - **$kgCO_2e$ /m³** (Cradle to Grave)



C25/30 EE2 - **mPt /m³** (Cradle to Grave)



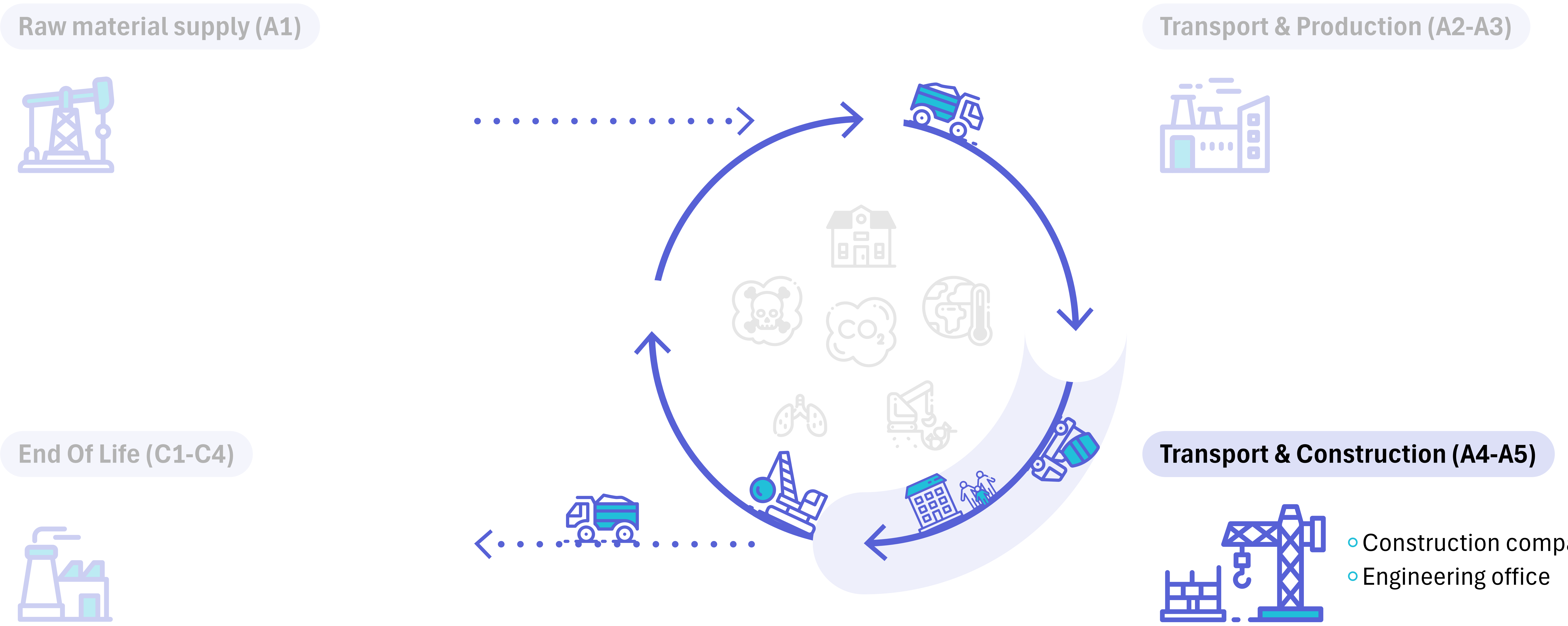
As discussed in the Buildwise magazine article (Sept-Oct 2025). In practice, the cement content of BENOR concrete is on average 10% to 17% higher than the minimal content imposed by the standard (Annex F from NBN B 15-001).

Limitations :

- The less clinker there is in cement, the smaller the reduction in impact.
- Decreasing the cement content and therefore the water content could cause implementation difficulties that need to be considered (Workability, ...).

The concrete life cycle

Raw material supply (A1) | Transport & Production (A2-A3) | **Transport & Construction (A4-A5)** | End Of Life (C1-C4)



- Construction company
- Engineering office

Transportation from concrete plant to construction site (A4)

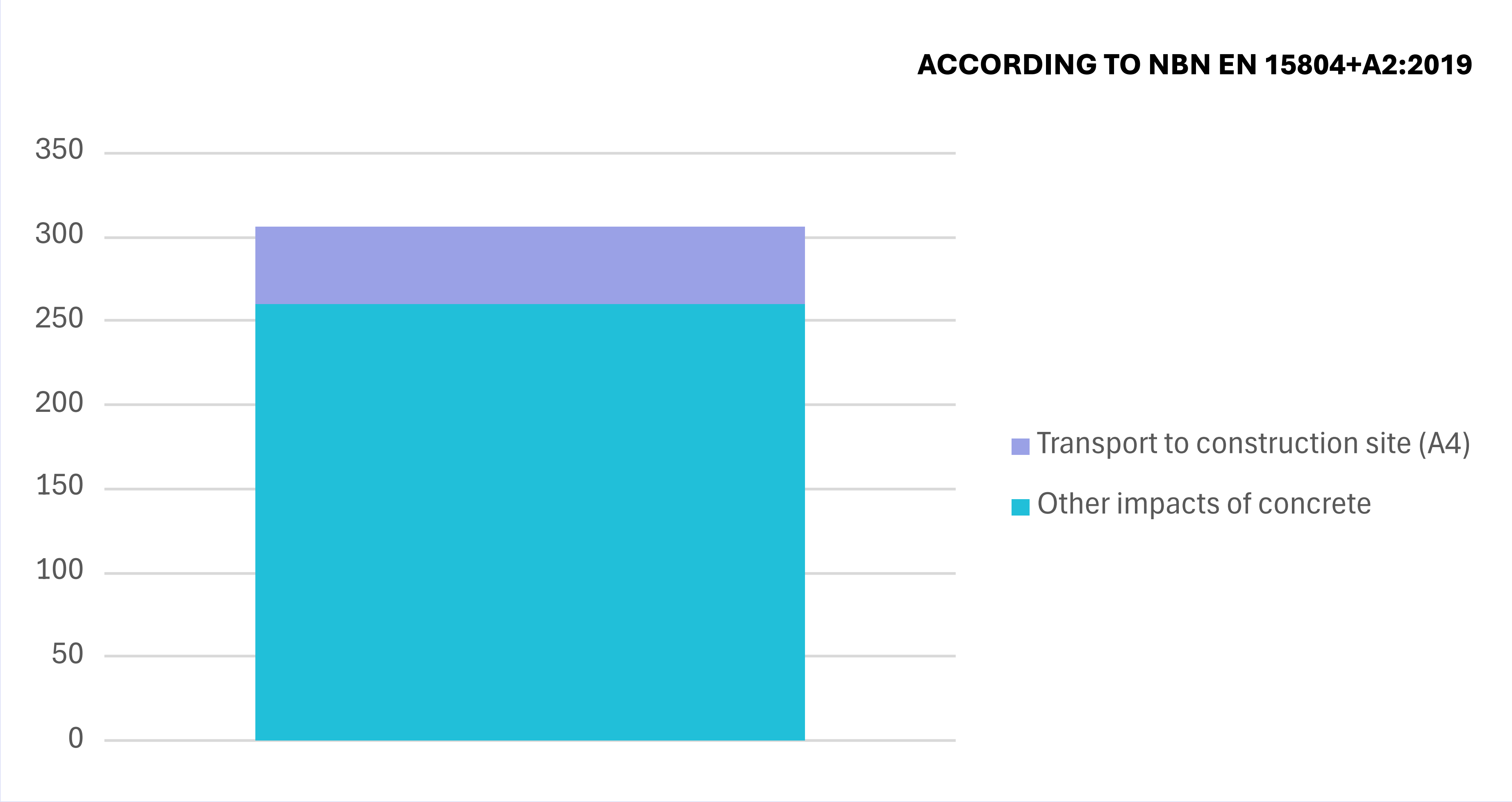
Choosing a closer concrete plant

Transportation to construction site accounts for approximately 15% of life cycle impact (climate change and multi-indicator approach) of concrete for a transportation over 100km.

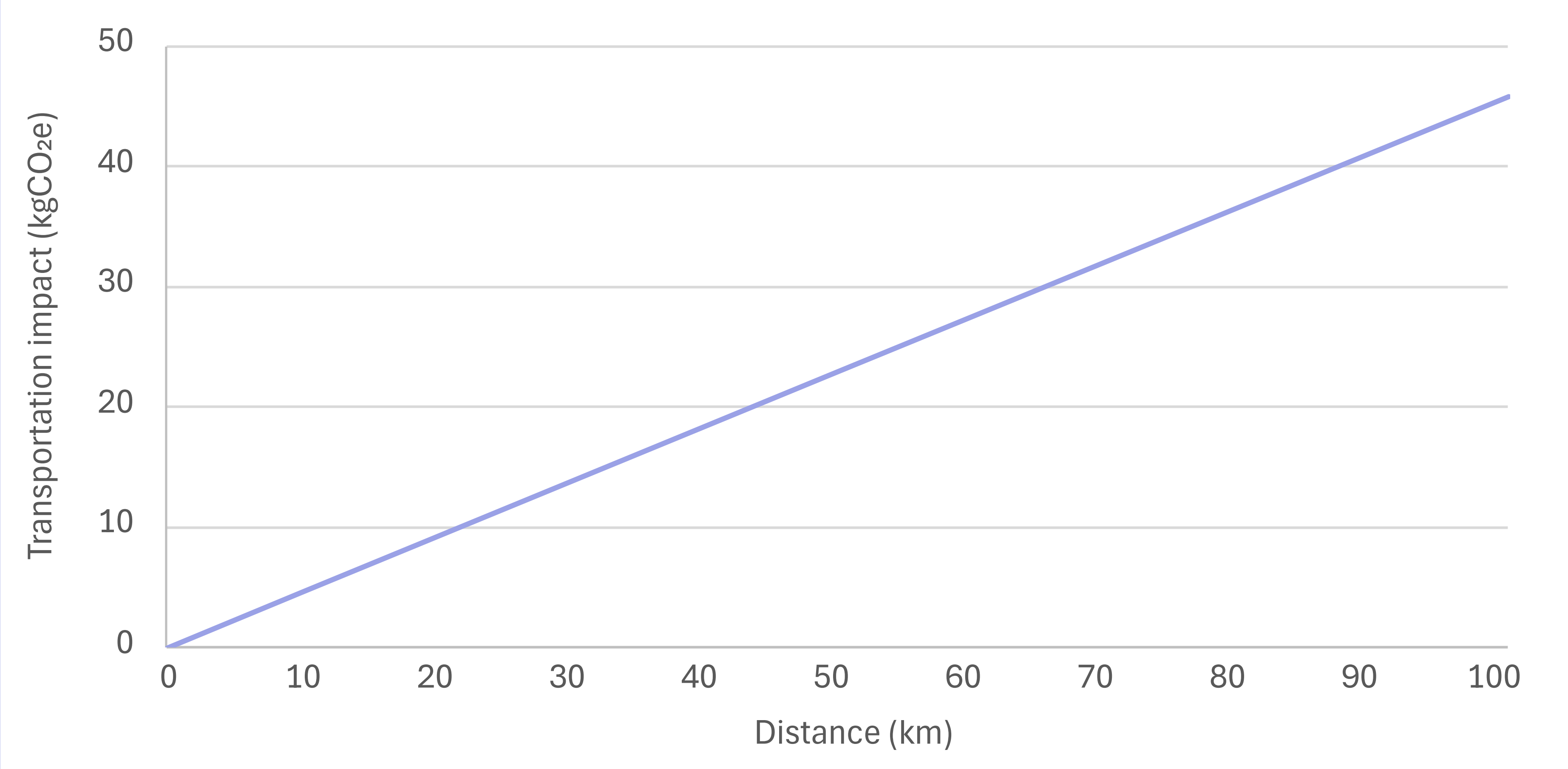
The concrete life cycle

Raw material supply (A1) | Transport & Production (A2-A3) | **Transport & Construction (A4-A5)** | End Of Life (C1-C4)

Concrete C25/30 EE2 - **$kgCO_2e$ /m^3** (Cradle to Grave)



Impact of transportation to construction site of $1m^3$ of C25/30 EE2 CEM III/A - **$kgCO_2eq/km$**



- For a given concrete and a transportation by truck, choosing the closest concrete plant could participate to the mitigation of the concrete impact by up to **15% (46 $kgCO_2e/m^3$ of concrete)** if the concrete plant is located near the construction site.

Limitations :

- 100km is the average transport distance for products produced in Belgium (B-EPD PCR). However, for concrete this is conservative assumption. 35 km would be more realistic.

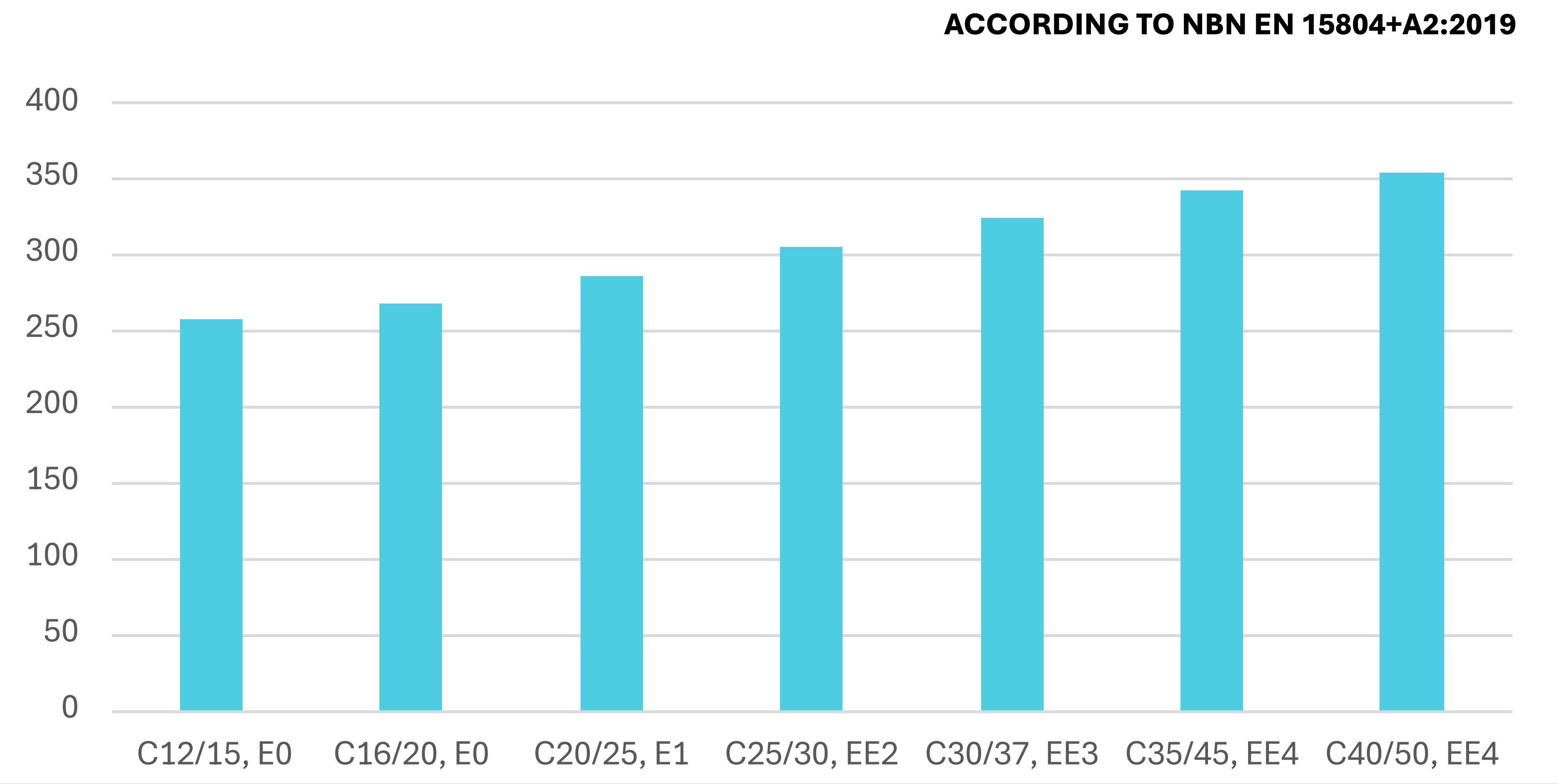
- To avoid transfer of impact from module A4 to module A2, the transportation of raw materials (A2) should also be optimised by the concrete plant.

Concrete strength and environmental class (A5)

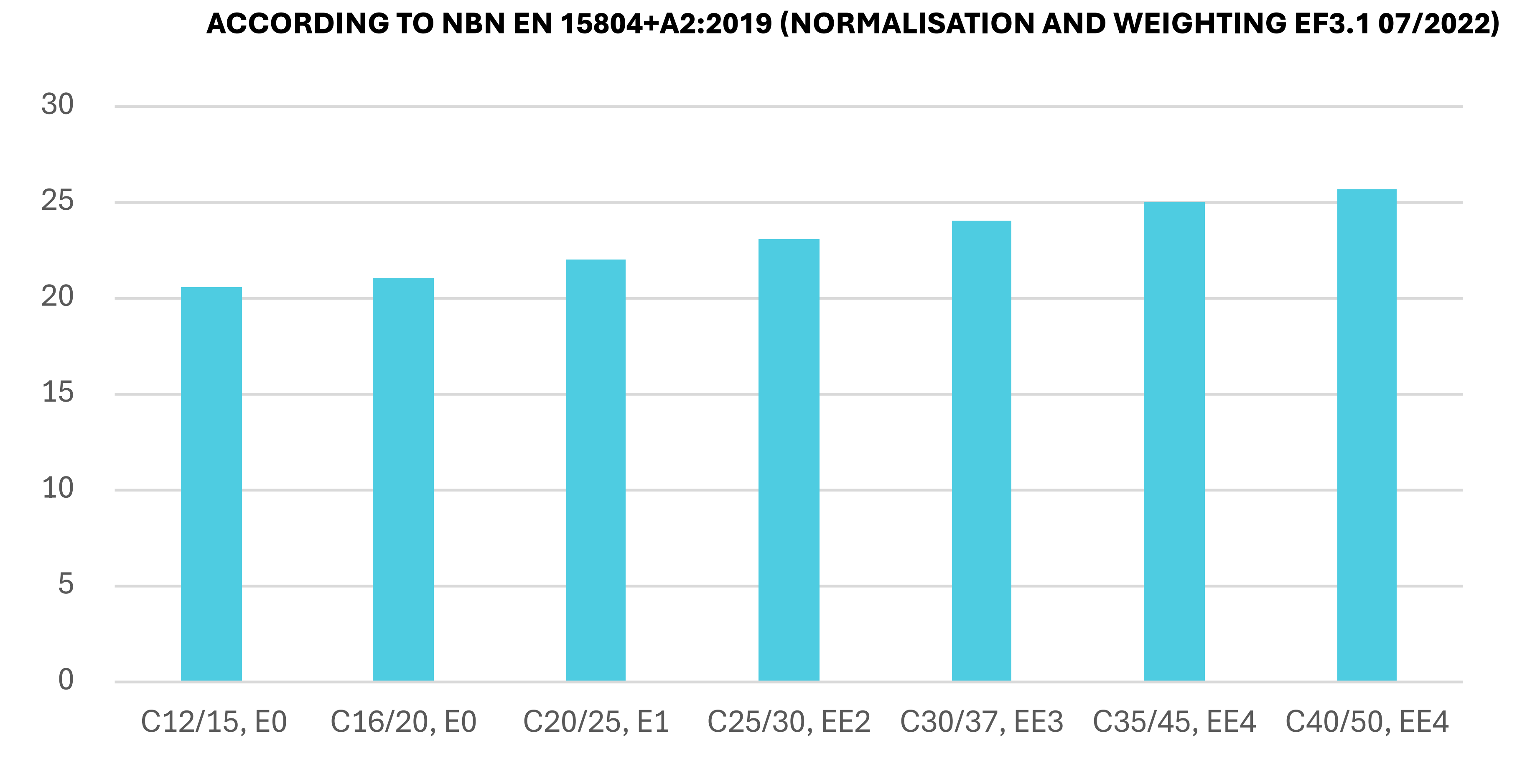
Appropriate strength for concrete

There is a difference of impact of around 30% in CO_2eq emissions and around 20% in mPt from a C12/15,E0 concrete to a C40/50,EE4 for the same type of cement.

Concrete with CEM IIIA - **$kgCO_2e/m^3$** (Cradle to Grave)



Concrete with CEM IIIA - **mPt/m^3** (Cradle to Grave)

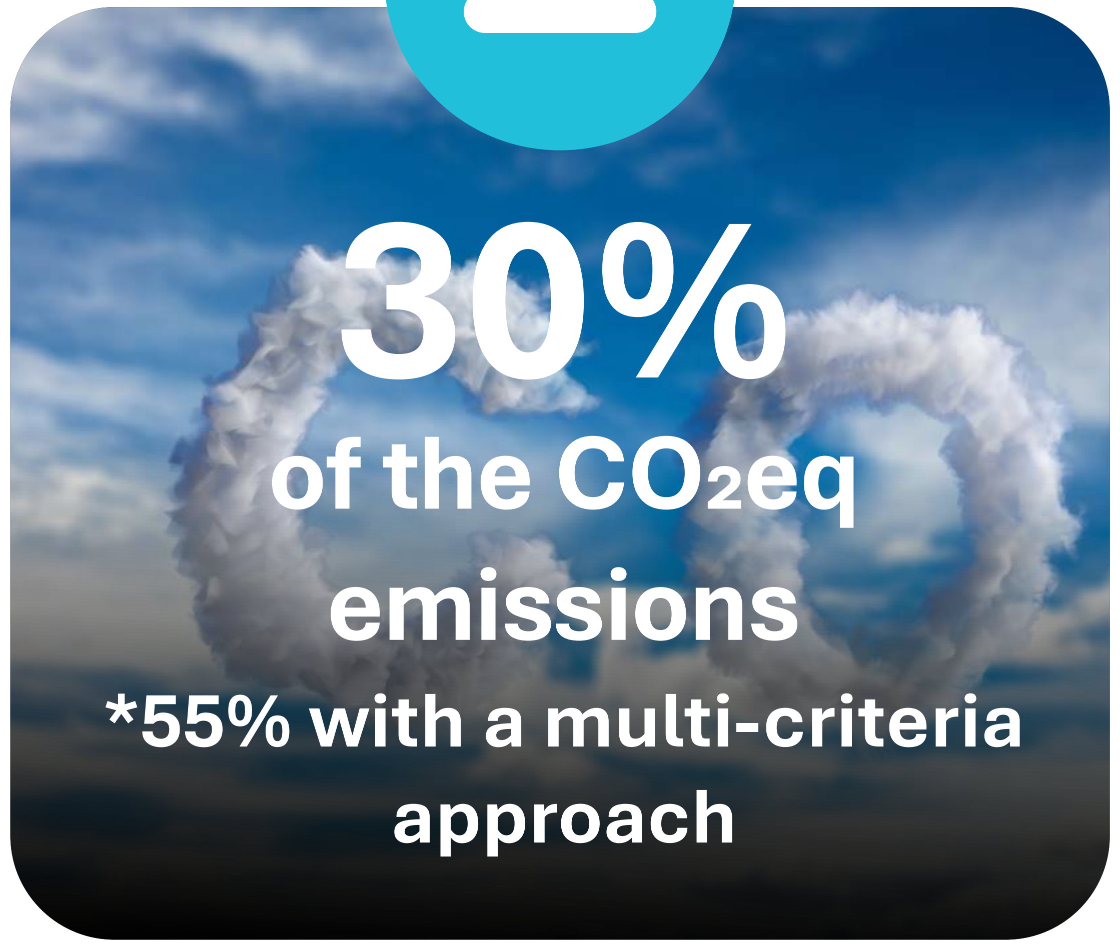


Choosing the most appropriate strength for concrete based on its application allows to limit the environmental impact of concrete structures.

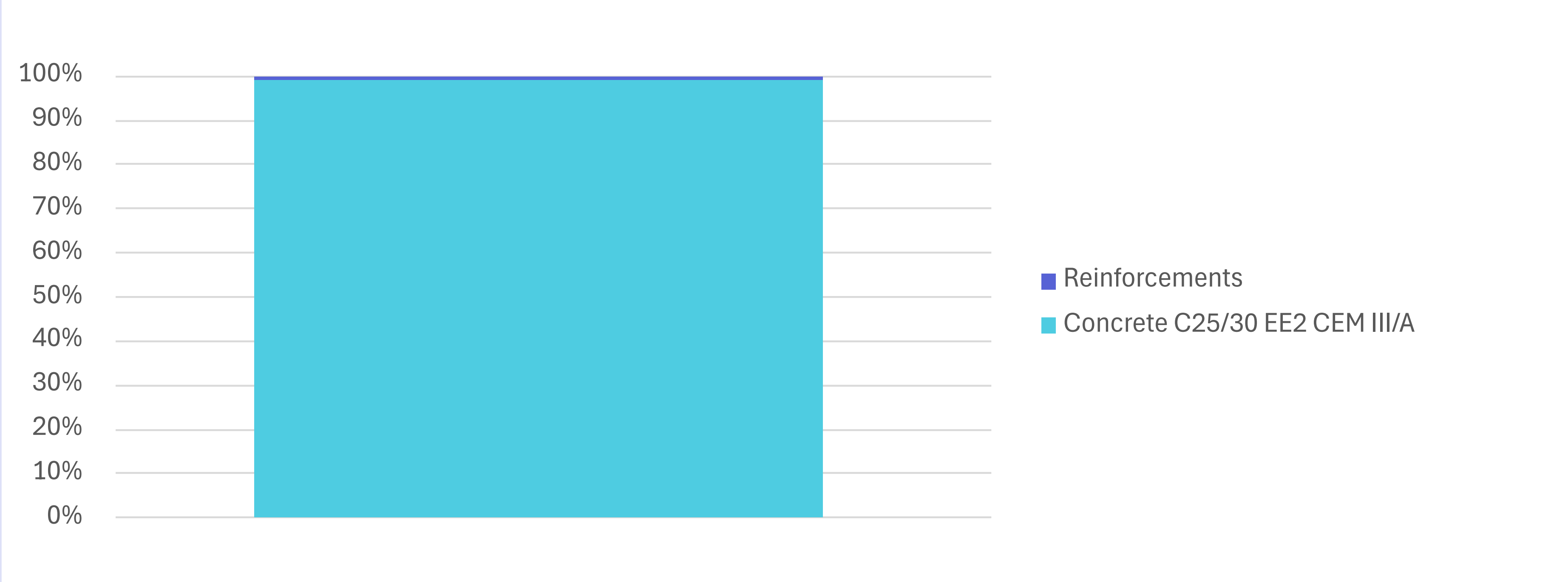
Limitations :

- Reducing the strength of concrete could imply the use of more concrete and therefore cancel out the benefit of having a lower impact per m^3.
- For reinforced concrete, reducing the strength of concrete can affect the amount of reinforcement required and limit the benefits associated with lower concrete strength. Consequently, the impact of both the concrete and the reinforcement must be taken into account simultaneously.

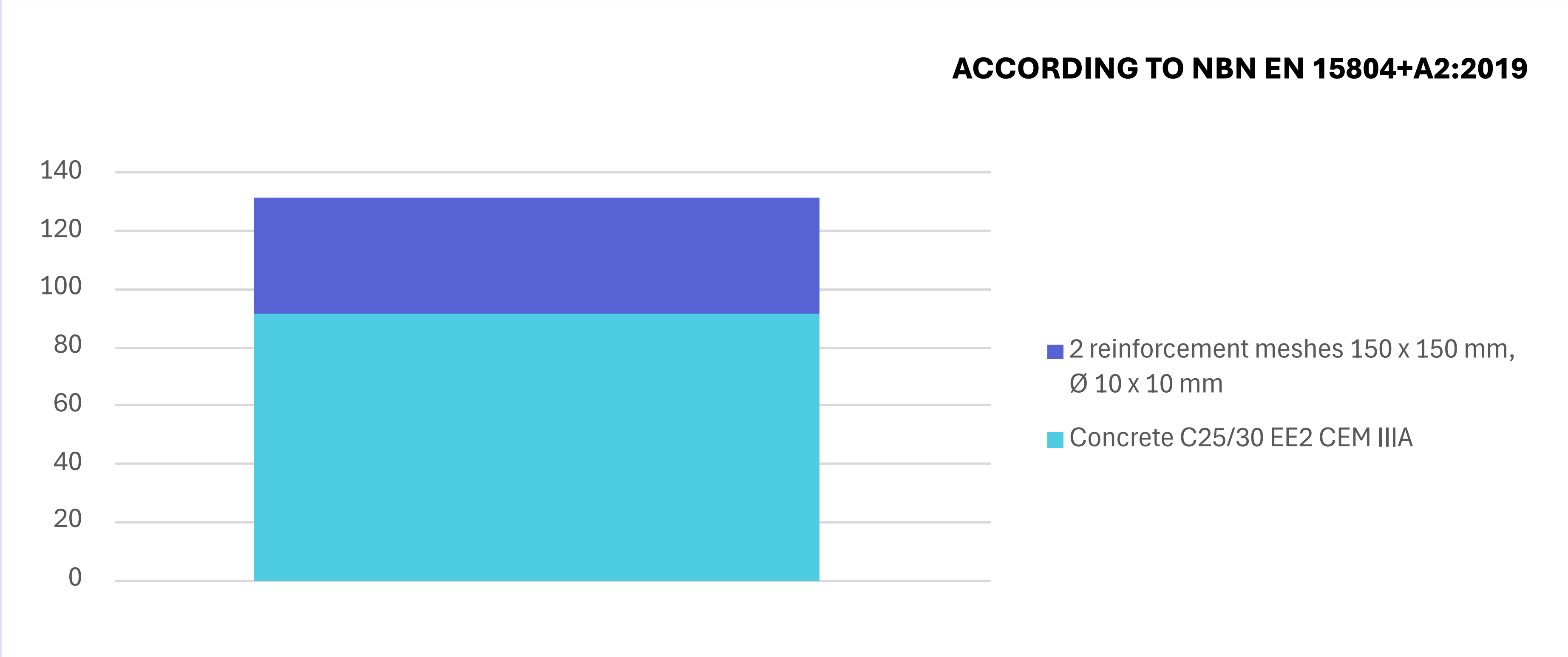
Reinforced concrete slab (A5)



Materials in reinforced concrete slab - Mass %

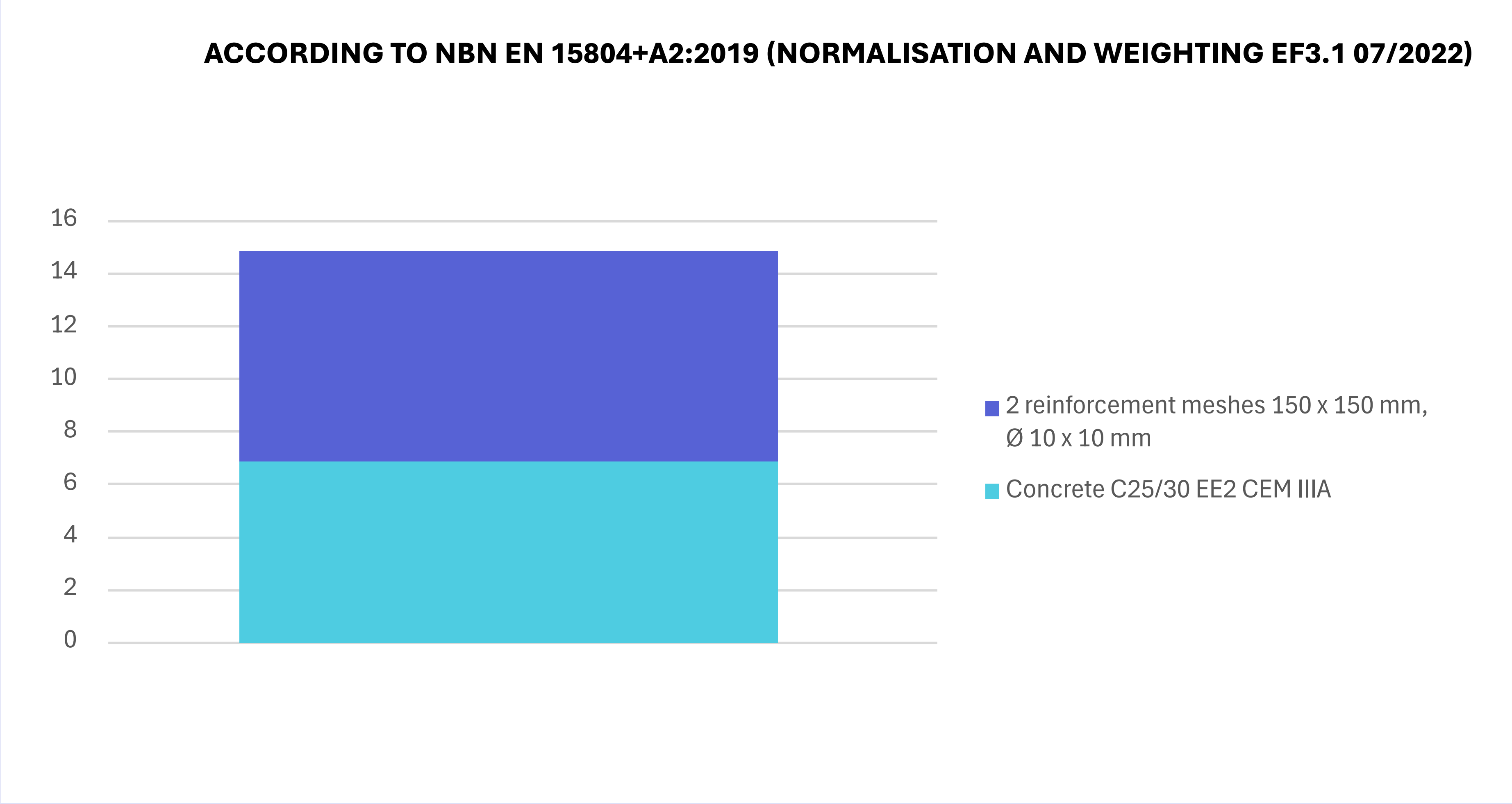


Reinforced concrete slab - **kgCO2e / m²**



In the reinforced concrete slab, reinforcements represent 1% in mass but is responsible for 30% of the CO_2eq emissions and 55% with a multi-criteria approach.

Reinforced concrete slab - **mPt / m²**



The impact of steel depends on the production process :

- Blast Furnace for primary steel.
- Electric Arc Furnace for recycled steel with particular attention to the electricity mix used.

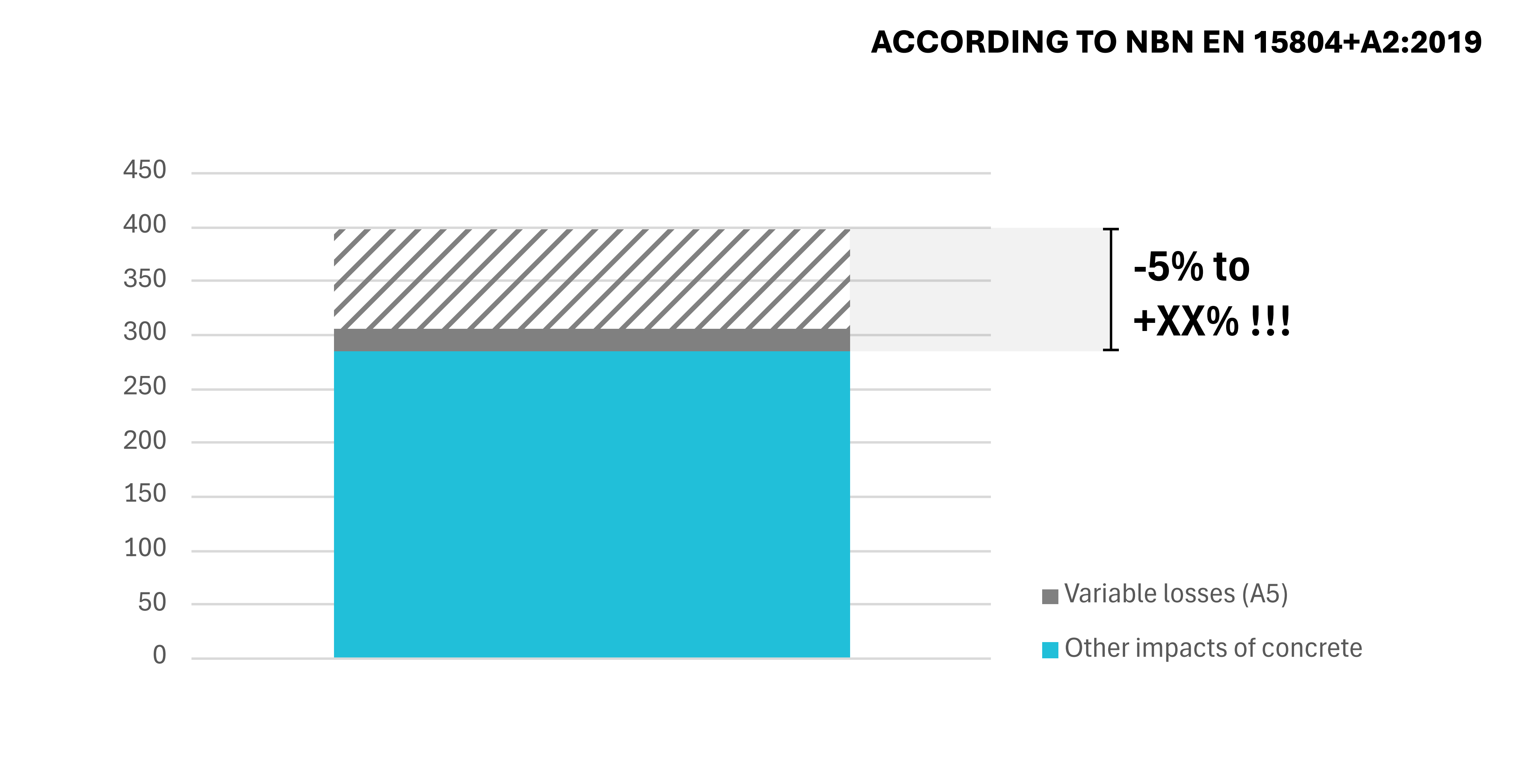
Optimizing the quantity of steel used is a priority to limit the impact of reinforced concrete.
Privilegiate recycled steel produced in Europe.

Limitations :

- Limited quantity of recycled steel available

Losses on construction site (A5)

Concrete C25/30 EE2 - **kgCO_2e /m^3** (Cradle to Grave)



Losses are highly variable according to the situation. An average loss of 5% is considered but it can be a lot more important.

➔ It is essential to ensure that the concrete produced is used.

Preservation of concrete structures - Reuse (A5)

New concrete

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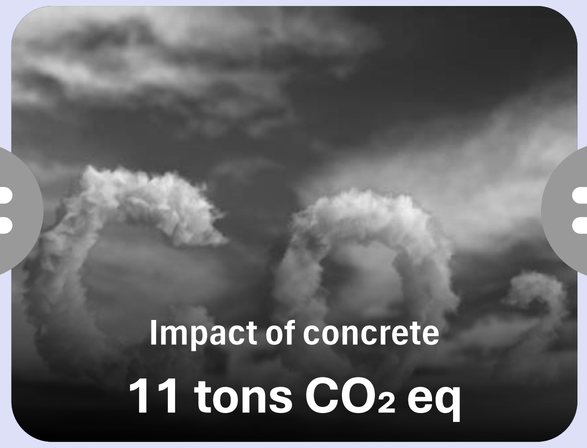

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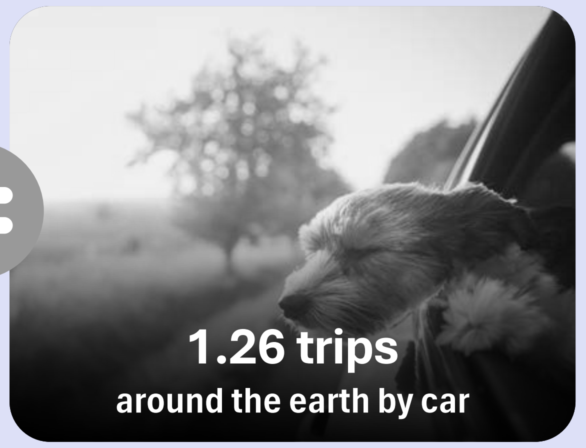

Reused concrete

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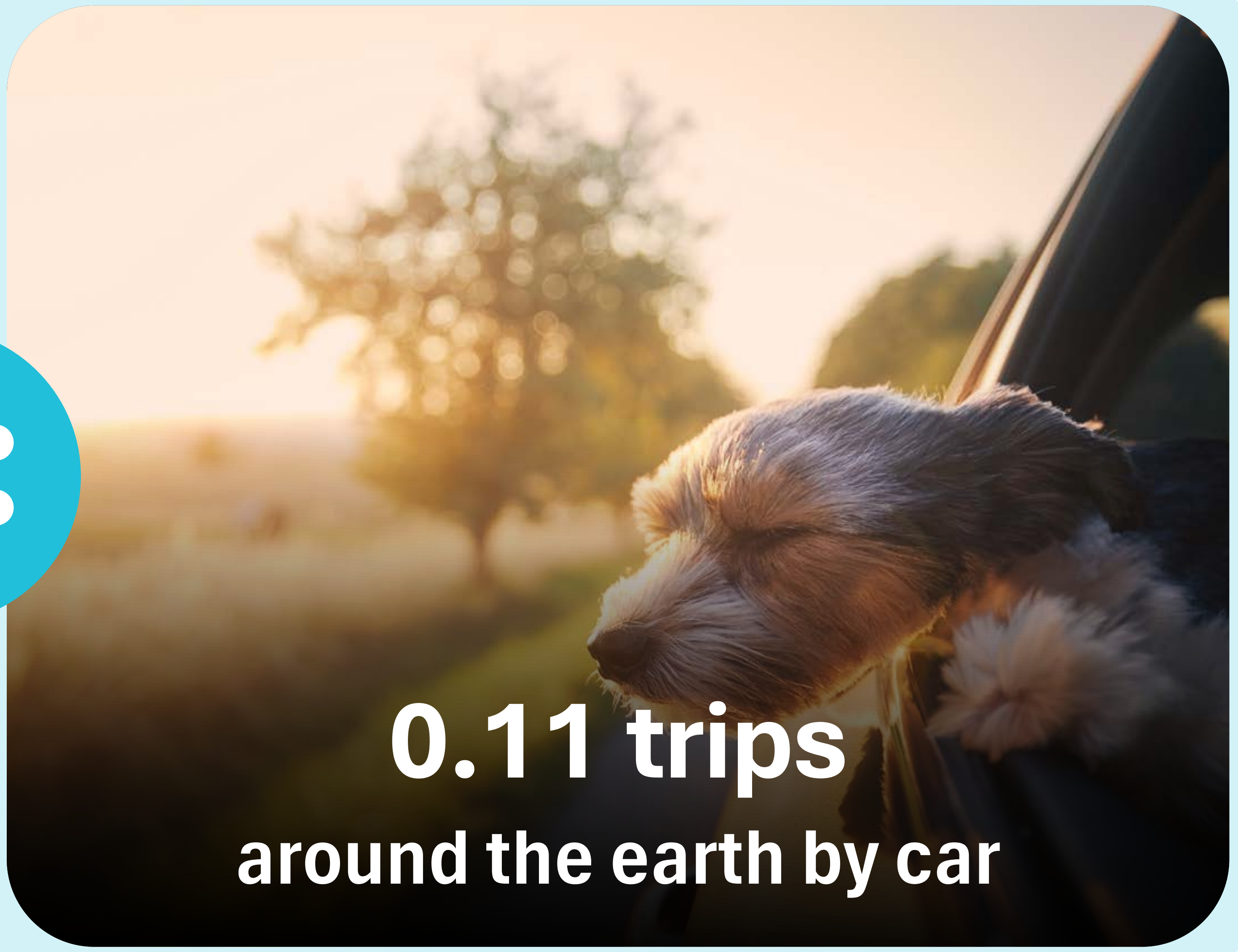
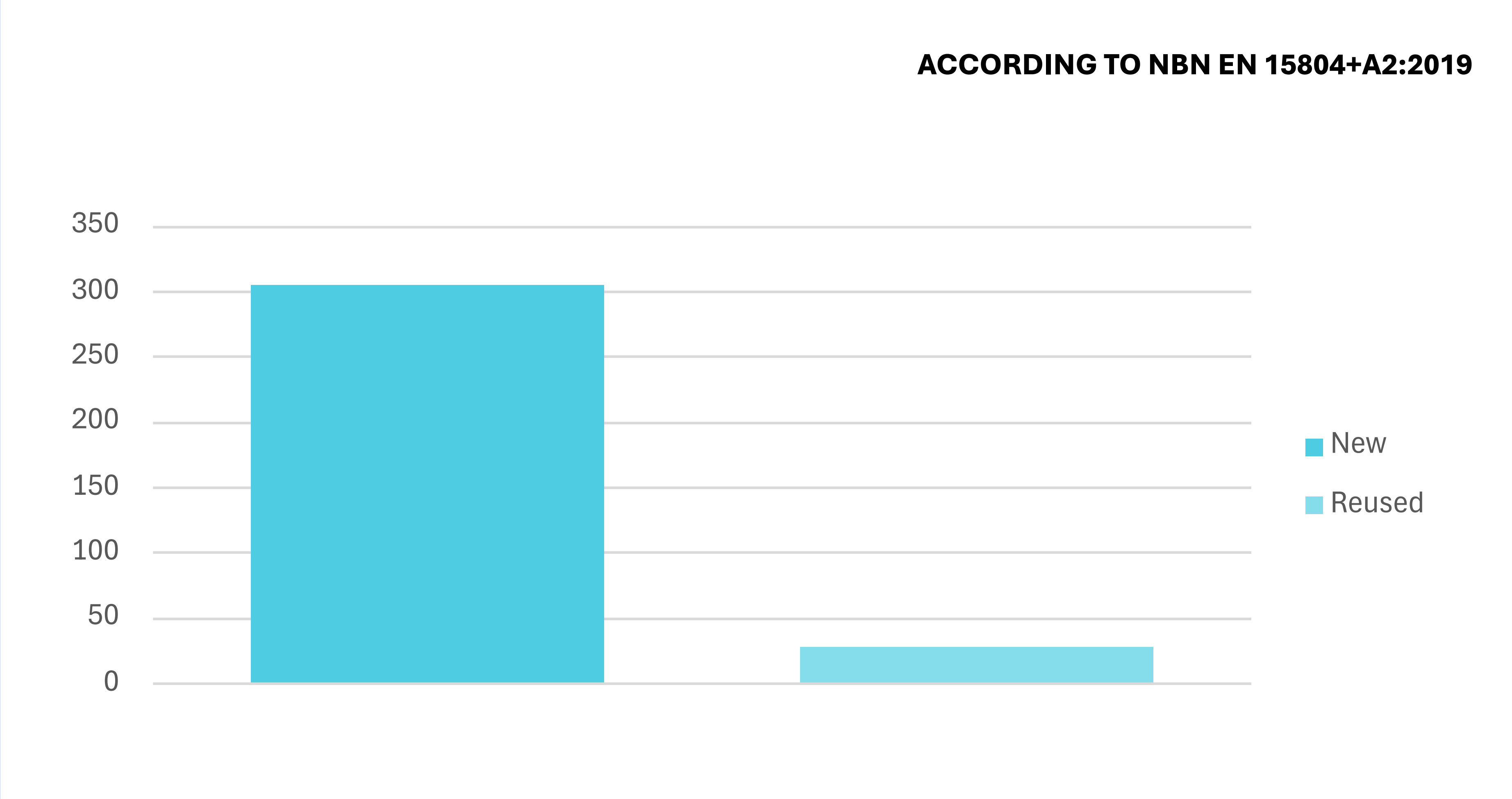
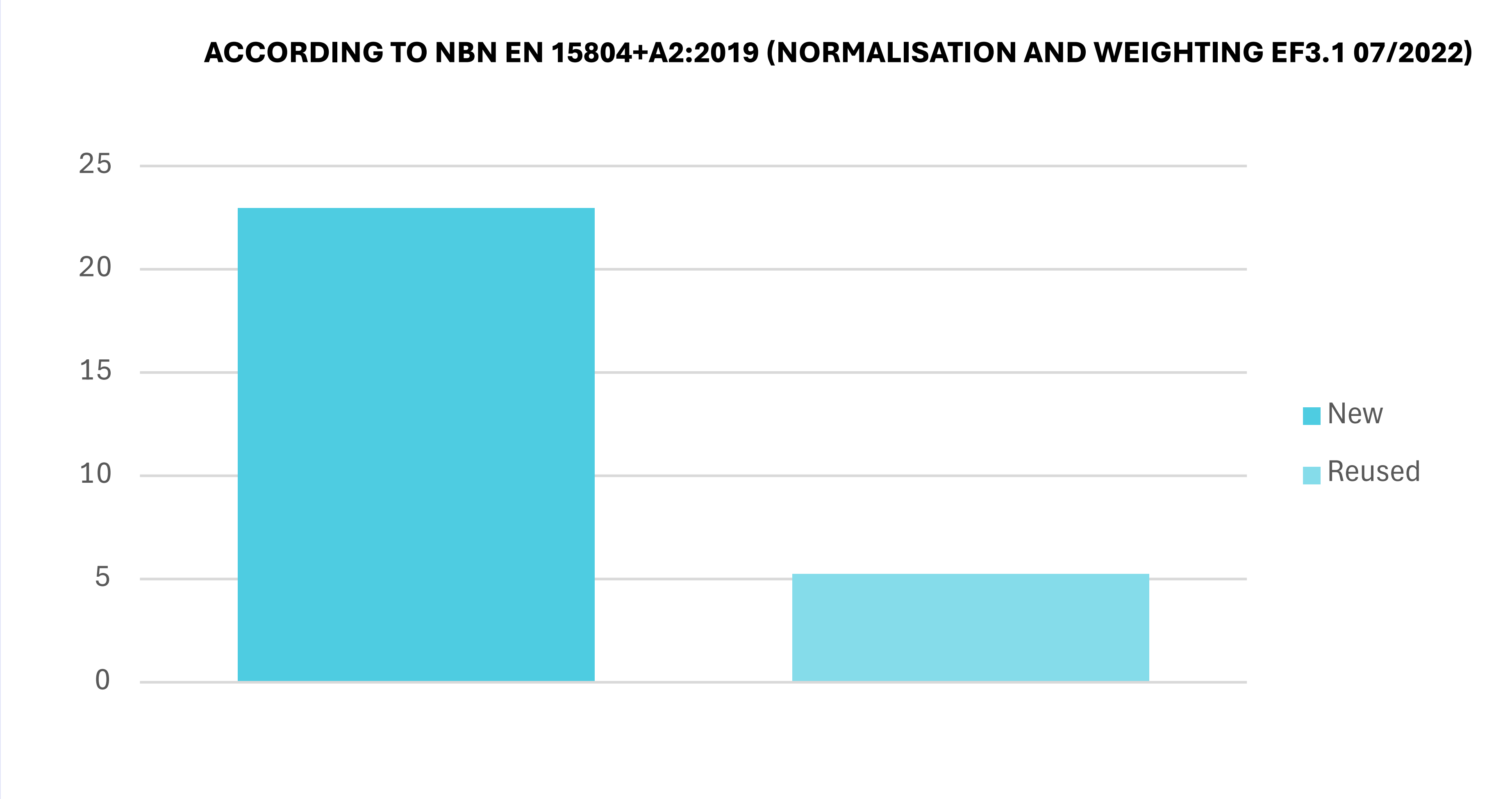


Concrete C25/30 EE2 - **$kgCO_2e /m^3$** (Cradle to Grave)



Concrete C25/30 EE2 - **mPt /m^3** (Cradle to Grave)



Reusing concrete in situ reduces CO_2eq emissions of concrete by 90% (and 80% using a multi-indicator approach) compared to a new concrete.

Preserving concrete structures avoid :

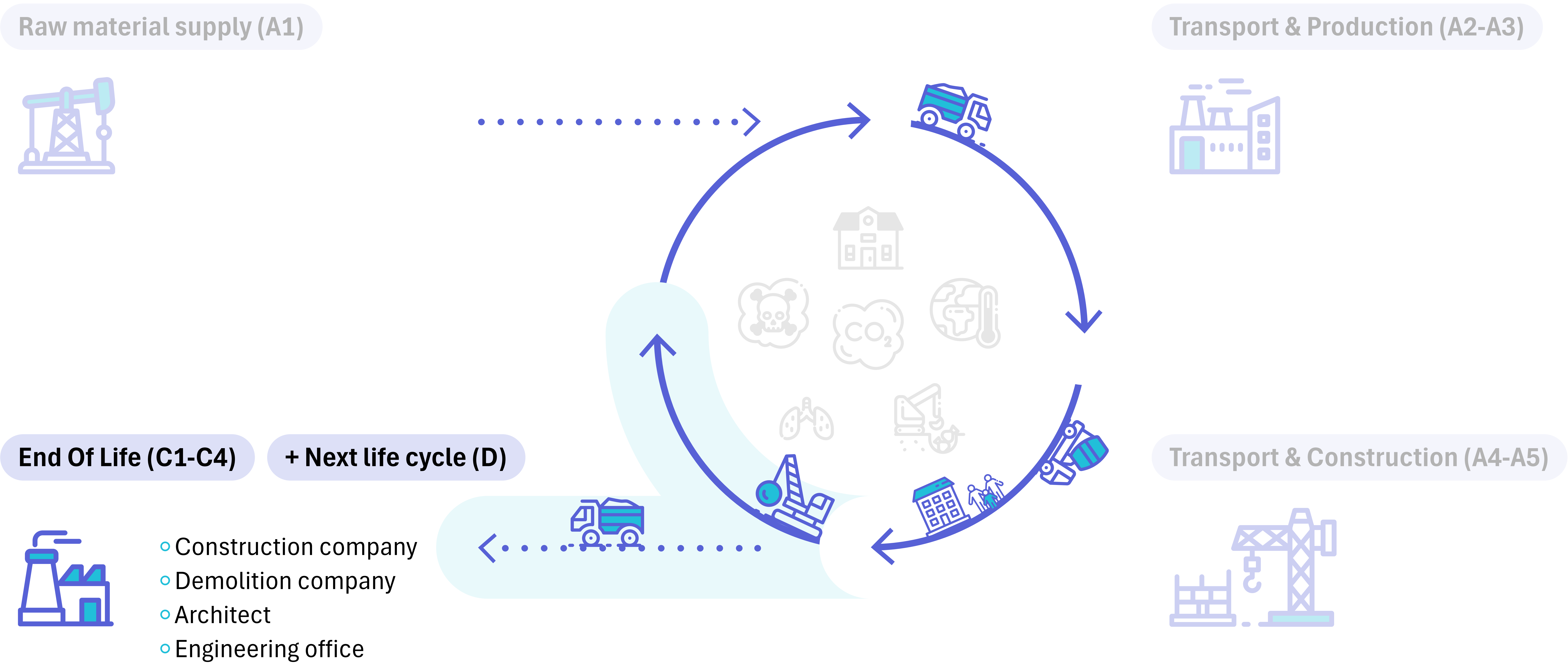
- Production (A1-A3) and construction (A4-A5) stages of concrete. Only the End Of Life (EOL) impact is taken into account.
- Impact of steel reinforcements (Not taken into account here)

Limitations :

- Concrete structure must be capable of withstanding a new life cycle (adequate concrete performance, etc.).

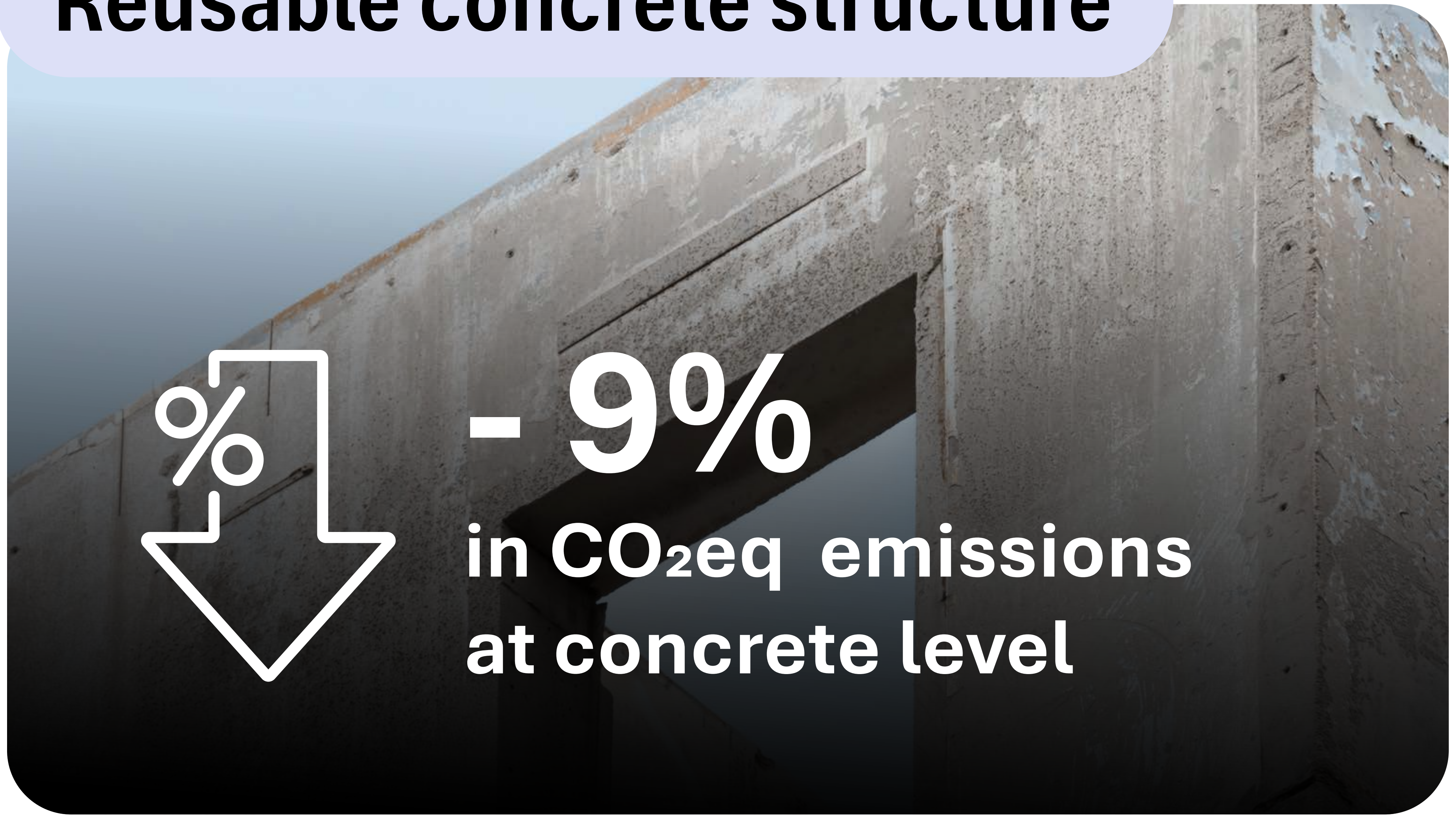
The concrete life cycle

Raw material supply (A1) | Transport & Production (A2-A3) | Transport & Construction (A4-A5) | **End Of Life (C1-C4)**



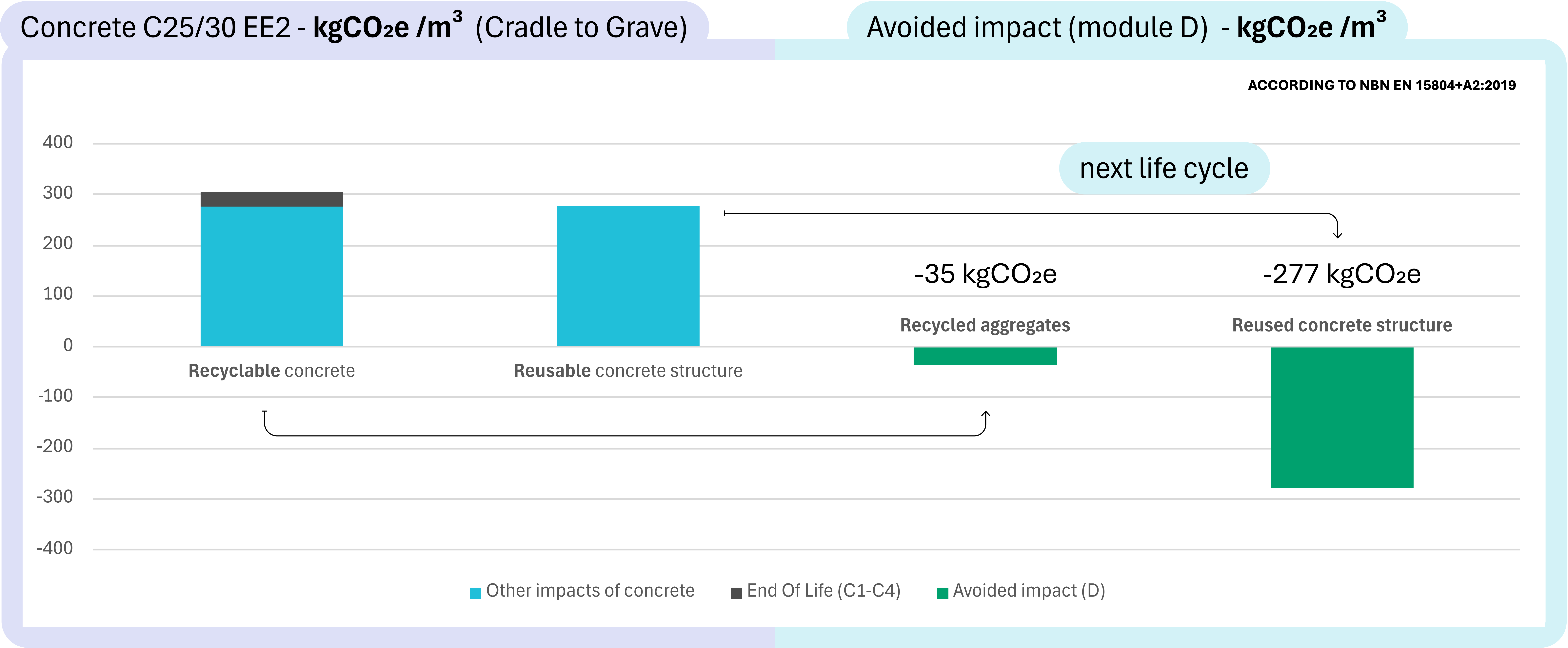
Recyclable and Reusable concrete at EOL (C1-C4 + D)

Reusable concrete structure



Having a reusable concrete structure reduces concrete GHG emissions by up to 9%.

- The emissions associated to deconstruction, transportation, treatment and disposal of waste are avoided.



During the subsequent life cycle, the avoided impact is maximised when the concrete structure is reused.

➔ Production, transport and installation of primary concrete are avoided.

Limitations :

The fact that a structure is reusable does not mean that it will actually be reused. To benefit from this reduction, special attention must be paid and specific measures must be taken to encourage reuse from the design and construction phase onwards.

The Concrete Life Cycle

Summary