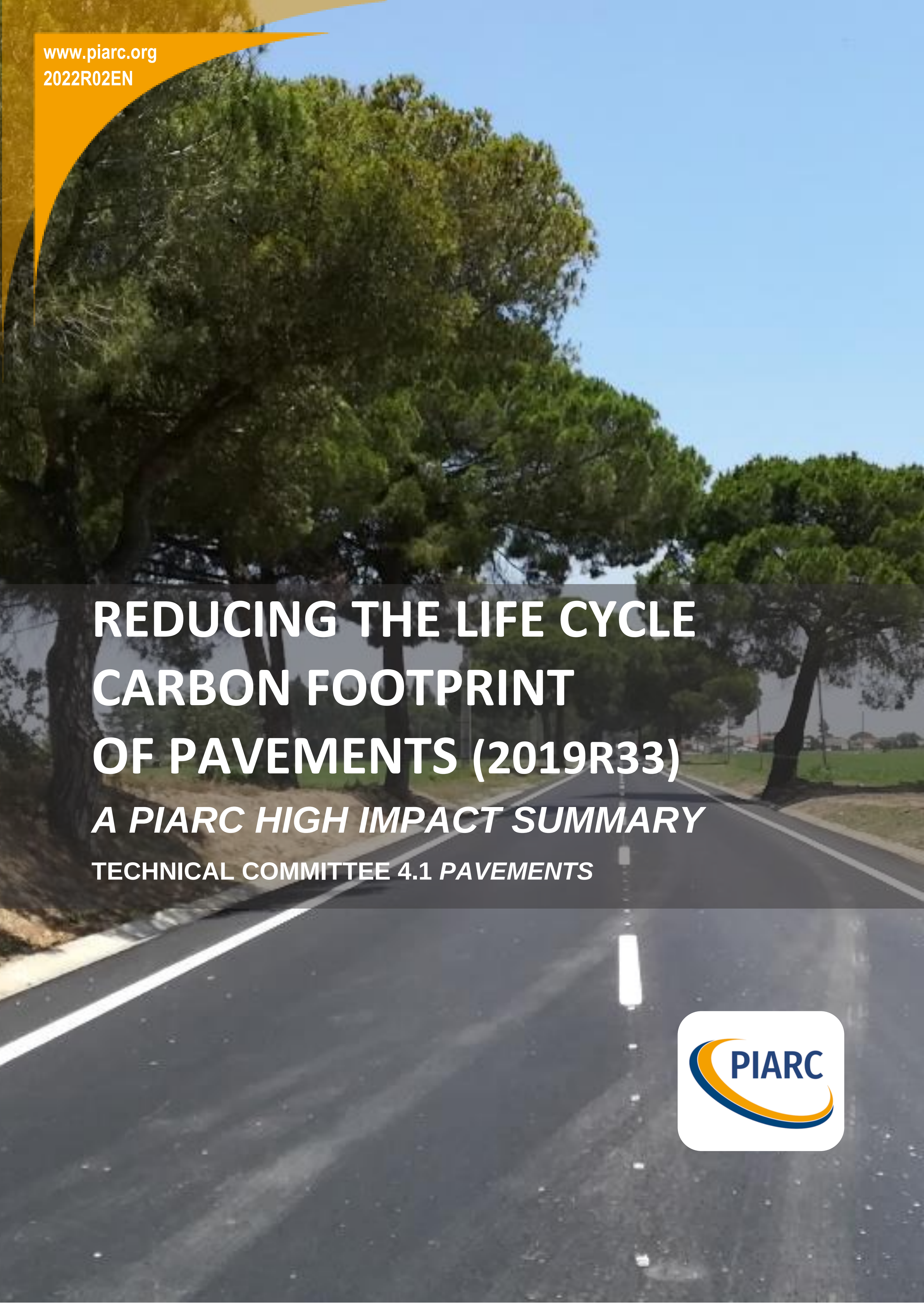

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2022R02EN

REDUCING THE LIFE CYCLE CARBON FOOTPRINT OF PAVEMENTS (2019R33)

A PIARC HIGH IMPACT SUMMARY

TECHNICAL COMMITTEE 4.1 *PAVEMENTS*

PIARC

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020–2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

This report is available from the internet site of the World Road Association (PIARC): http://www.piarc.org

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A PIARC HIGH IMPACT SUMMARY

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EXECUTIVE SUMMARY

2022R02EN

REDUCING THE LIFE CYCLE CARBON FOOTPRINT OF PAVEMENTS

A PIARC HIGH IMPACT SUMMARY

In 2019 PIARC published the report "Reducing the life cycle Carbon Footprint of pavements" (2019R33), which was a result from the work conducted by the Technical Committee D.2 – Pavements, during the 2012-2015 cycle. This report assessed and synthesized recent innovations leading to the reduction of Carbon Footprint of pavements. It also presented a critical review of the Carbon Footprint reductions achieved by various innovative technologies when compared to standard methods of construction including the use of reused, recycled, and recovered materials.

The current high impact summary, condenses and highlights the following principal topics which were deeply studied and analysed in the report:

- summarizes the concepts behind Carbon Footprint Reduction.
- identifies the studied models by the Technical Committee D.2 – Pavements, during the 2012-2015 cycle.
- synthetises the Survey's results regarding the measurement of Carbon Footprint around the world
- lists some innovations reported to reduce Carbon Footprint.
- presents the most significant conclusions and recommendations from the report "Reducing the life Cycle Carbon Footprint of Pavements (2019R33)".

CONTENTS

1. INTRODUCTION

In 2019 PIARC published the report “Reducing the life cycle Carbon Footprint of pavements”, which was a result from the work conducted by the Technical Committee D.2 – Pavements, during the 2012-2015 cycle. This report assesses and synthesizes recent innovations leading to the reduction of Carbon Footprint of pavements, such as warm mix asphalt technologies. It also presents a critical review of the Carbon Footprint reductions achieved by these technologies when compared to standard methods of construction including the use of reused, recycled, and recovered materials.

The scope of the report was limited to Carbon Footprint issues, although it presents and clarifies other sustainability aspects associated with road pavements. The report considers aspects affecting the Carbon Footprint of road pavements over the life cycle of the pavement, from raw material acquisition to end of life which may include re-use and/or recycling of its constituents. The “in-use” phase of the life cycle was considered out of scope. As such, the report primarily focuses on the design, construction, and maintenance of pavements. It should be noted that the lack of the use phase may result in an incomplete assessment of the lifecycle Carbon Footprint on pavements, which may lead to an imprecise final evaluation.

The definition of sustainability and sustainable development is enhanced to reflect road construction industry with emphasis on preserving resources and reducing carbon emissions. As defined in the report. Sustainability is often described as a quality that reflects the balance of three primary components: economic, environmental, and social impacts, which are often collectively referred to as the “triple-bottom line”.

Carbon Footprint, a generic term referring to the life cycle equivalent Greenhouse Gas emissions (GHG), is discussed and explained. Carbon Footprint is one of the outcomes from a Life Cycle Assessment (LCA – Standardized method ISO 14040, ISO 14044) used to model the potential impact to global warming/climate change. The report defines system boundaries, explains the importance of allocation methods, and discusses key considerations for comparability of results. With these principals in mind, the report identifies several tools available that can be used to assess the carbon footprint of pavements.

2. MODELS AVAILABLE TO ASSESS CARBON FOOTPRINT

Eleven software tools to assess a road project's potential environmental impacts, used by different countries, were critically reviewed in the report. These tools differed from each other in terms of their content, friendlessness of use, focus and, environmental indicators (CO2 equivalents, energy, material weight, etc). Almost all tools assessed were designed to assess asphalt and concrete pavements.

The software tools analysed were: SEVE, ECORCE, HACCT, AsPECT, CHANGER, DUBOCALC, GHGC, PALATE, CEREAL, EKA and TAGG Carbon Gauge Calculator Tool.

The report summarizes the main features associated with each tool, including:

- Country which developed tool.
- Outcomes (Environmental Indicators).
- If it is design/construction process oriented, life cycle oriented, or asphalt plant oriented.
- Main characteristics and procedures.
- Principal useful aspects.
- Potential drawbacks and inconveniences.

To compare the tools, and the stages they assess, the road pavement lifecycle stages represented in table 1 (EN 15804 – Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction works) were used. Benefits and loads beyond system boundaries were considered as stage D. To understand this table, the following key should be used: dark blue = covered in detail, light blue = covered more superficially, white = not covered.

	Production stage			Construction stage		Use stage		End-of-life				beyond system boundaries
asPECT	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
CHANGER	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
DUBOCALC	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
ECORCE	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
GHGC	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
HACCT	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
PALATE	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
SEVE	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
EKA	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D
CGCT	A1	A2	A3	A4	A5	B1	B2-4	C1	C2	C3	C4	D

Table 1-Stages for a road pavement life cycle.

The analysis of the tools considered the complexity associated with the calculation of Carbon Footprint, as well as the differences between the source data, assumptions, and systems boundaries. Even when the input data type is the same, the outcomes may differ significantly due to different data sources and differing system boundaries.

Most of the Carbon Footprint software tools analysed cover the production and construction stage of a road pavement, although with differences between the focus of each tool. None of the analysed software's take into consideration the "in-use" phase of the pavement. Some tools also incorporate maintenance and repair phase. Only one tool presents considerations outside the system boundaries: the recyclability of materials.

The outcomes from the analysed tools differ. All tools express the Global Warming Potential as $CO_{2equivalent}$ [1]. Some tools cover other environmental impacts established in the EN 15804.

The report summarizes each tool, identifies the life-cycle stages covered, and highlights the level of detail associated with each stage. It also presents a comparison of the environmental indicators assessed by the different models since some models consider other environmental impact indicators other than $CO_{2equivalent}$.

The strengths and weaknesses of the software depend on the purpose for which they are intended to be used. Some tools focus on the whole life cycle while others focus only on the construction stage. The report presents a comparison between the different Carbon Footprint tools studied considering their approach and flexibility. The choice of which tool depends on the user's needs. Two categories of tools could be identified: one type of tools was created for detailed mixture composition analysis and the second type of models were a cradle-to-grave life cycle analysis of pavements.

In the figure 1, taken from the report, all the Carbon Footprint tools are put into quadrantes according to each tool's flexibility (more options which can be user-defined); and according if it is more design oriented (focusing on the mixture production stage) or project oriented (addresses questions like posing, use, maintenance, and end-of life stage).

[1] Since the report was published it was noticed that all tools expressed outcomes in GWP.

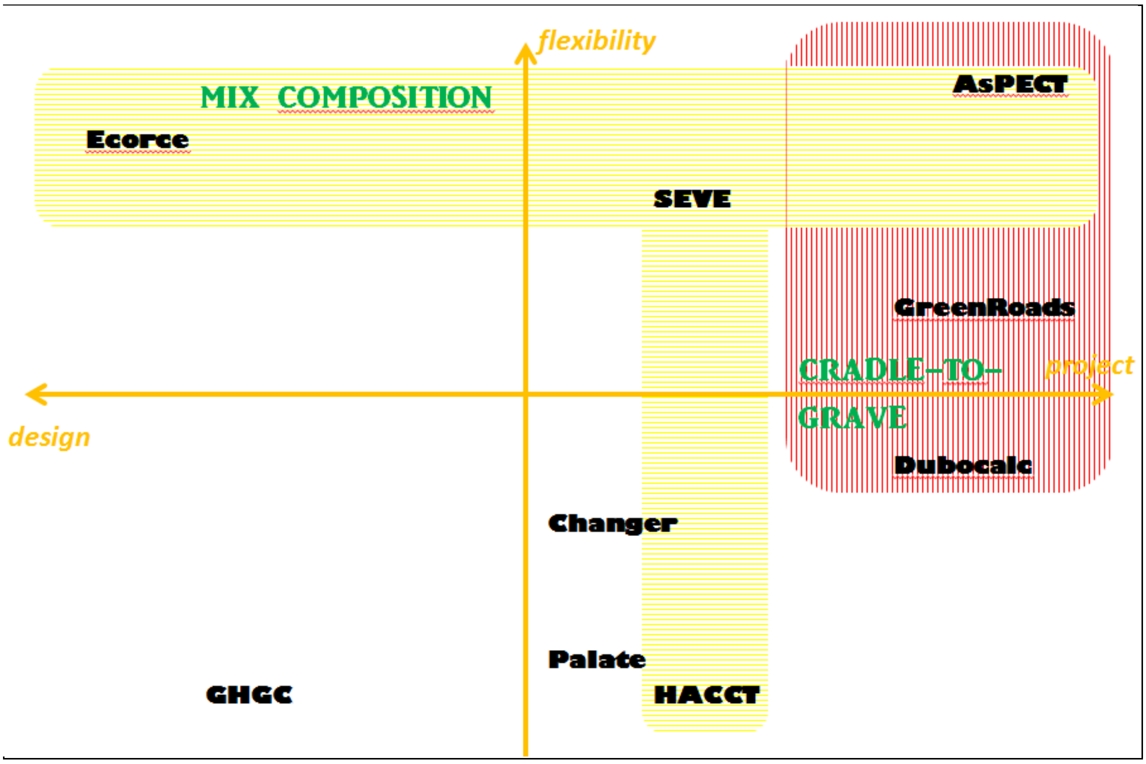

Figure 1: Studied Carbon Footprint tools with" mixture" and "cradle-to-grave" categories.

From this analysis it is possible to conclude, that from a perspective of mix composition analysis, Ecorce, SEVE and AsPECT are helpful to the user. On the other hand, if the user intends to tackle the whole life cycle, AsPECT, GreenRoads and Dubocalc are more suitable options.

3. SURVEY REGARDING MEASUREMENT OF CARBON FOOTPRINT AROUND THE WORLD

A survey was conducted in the form of a questionnaire to establish which countries around the world were measuring the Carbon Footprint, and how and why they were collecting and using the collected information. The questionnaire can be consulted in the report, as well as the summarized answers. The questionnaire received twenty-three answers, from countries in Europe (14), America (4), Oceania (2) and Asia (3).

From the answers it was possible to conclude the following:

- 13 countries have a National Action Plan for Green Public Procurement, and 2 countries responded that guidelines and a strategy plan is available concerning these matters.
- 5 countries consider Carbon Footprint in construction and maintenance in pavement construction. For each of these countries the name of the organization responsible for this policy is noted, which phase of the road construction the Carbon Footprint is being assessed, and what is the framework in which the Carbon Footprint is used in the construction.
- 5 countries noted that they do not have a National Action Plan for Green Public Procurement reported but they have plans to consider Carbon Footprint are underway.

- 7 countries reported that models, which enable environmental criteria to be considered for Public Procurement projects for Road Pavements, are available, and some examples were presented.
- When models are used, in general the models contain default values for emission calculation. Commercially available databases are typically the source for these data.
- All the models appear to consider the main elements of the construction, although the energy used during the in-service phase of the product life cycle are not considered. None of the models currently evaluates the use-phase of the pavement. However, some of the models consider energy used by street lighting.
- Not all the models comply with international standards for Life Cycle Analysis (ISO 140000).
- 17 countries affirmed to be aware of technical innovations for road pavements to reduce the Carbon Footprint and provided examples. However, most of the countries, could not explain how the environmental claims of the referred innovations were quantified.
- 10 countries presented case studies that could support the reduction in Carbon Footprint from the innovations referred on the report.
- All the 23 countries listed the materials used in road pavements.
- Regarding if there existed any incentives to encourage Carbon Footprint reduction, only Netherlands responded that environmental criteria are routinely used as part of the bid process. France reported that Carbon Footprint is frequently used to select the most appropriate solution in the basis of several environmental indicators. Several countries reported that legislation on waste streams exists, requiring certain percentages of secondary materials to be recycled. Belgium reported that asphalt plants using more than 20MW are taxed for CO_2 emissions, and UK reported indirect incentives as lower energy/material bills.

4. INNOVATIONS REPORTED TO REDUCE CARBON FOOTPRINT

The report presents a review for each reported technical innovation and identifies in which stage of the product lifecycle (table 1) there are likely to exist impacts in Carbon Footprint, as well as some explanation of the process and scope for the reductions. It should be noted that most of the answers referenced innovations with the thought that they were more sustainable, but many did not quantify the reduction of Carbon Footprint of the road pavement. A deeper analysis can be consulted at the report.

A chapter of the report is aimed to the innovation's techniques reported to reduce Carbon Footprint, where a more detailed overview is provided on the following:

- Dry stockpiles for asphalt production.
- Warm mix asphalt.
- Re-use recycled and secondary material use.
- Two-layer concrete.
- Technologies for construction.

5. CONCLUSIONS AND RECOMENDATIONS

The main conclusions from the report are as follows:

- Although the innovations identified on the report claim to reduce Carbon Footprint, they do not necessary affect the Carbon Footprint of the pavement. Despite this, they may contribute for more sustainable construction with other benefits such as reduction in virgin material use. For example, the re-use and recycling of pavement materials contribute largely for the reduction of raw materials, but do not clearly show evidence of reduction of Carbon Footprint.
- There is a wide interest in sustainable solutions regarding pavement construction, however the information available is scarce, and engineers might be using innovative technologies without access to adequate data to quantify the claimed Carbon Footprint reduction.
- Many countries may have a National Plan to reduce Carbon Emissions, however many of those plans do not include pavement construction.
- In many cases there is no mechanism in place to measure and manage the GHG emissions during the design and construction of pavements.
- When using different models, and comparing their outcomes, the different assumptions, systems boundaries, and input data of each model must be considered to achieve concise results in terms of evaluation of Carbon Footprint.
- Regarding road construction, assessment of Carbon Footprint should include the lifecycle stages from raw material acquisition to pavement construction.
- In terms of sustainability, it is important to look at the innovative techniques that claim to reduce the Carbon Footprint, not only in terms of emissions, but also in terms of other beneficial environmental aspects, such as the reduction of consumption of virgin materials.
- When analysing an innovative technique used in the construction of road pavements, all processes necessary to perform that technique should be included in the analysis to assess the Carbon Footprint, e.g., warm mix asphalt (from mixing production to placing the layer).
- The present report did not consider the “in-use” phase of the lifecycle of a pavement, which has an elevated contribution to Carbon Footprint because of the fuel used by traffic. Despite this, the report recognizes that a well maintained and smooth pavement can reduce the fuel consumptions. Consequently, a pavement with an adequate routine maintenance can contribute to the reduction of the Carbon Footprint, by reducing the fuel consumption.
- The responses from the questionnaire showed that there are currently no incentives provided by road owners to encourage the adoption of lower Carbon Footprint Pavements. In a few countries’ models are available to assess Carbon Footprint of various solutions for specific projects, however only Netherlands uses routinely those models as part of the bid process.
- Carbon Footprint is not the only important environmental sustainability criterion, and other important sustainability criteria should be considered during the production and construction phase of the lifecycle.

Although the report only analysed the Carbon Footprint of road pavements, it is recommended that future projects should consider other environmental impacts relevant for sustainability using LCA methodologies.

The report « Reducing the life cycle Carbon Footprint of Pavements (2019R33) » is a result of the work developed by the Pavements Technical Committee during the cycle 2012-2015 and reflects the existing information at that time. More developments regarding this issue have occurred since 2015, however this is considered out of the scope of this report. The report is a high-level summary. For better understanding of reducing the lifecycle carbon footprint of pavements and more technical details, additional reading is necessary.

6. GLOSSARY

Term	Definition
CF	Carbon Footprint
$CO2_{equivalent}$	Conversion of GHG into CO2 that would provide the same amount of radiative forcing.
GHG	Greenhouse Gas
GWP	Global Warming Potential
LCA	Life Cycle Assessment

7. REFERENCES

[1] PIARC (2019) Reducing the life cycle carbon footprint of pavements, 2019R33EN, Technical Committee D.2 Pavements, available at www.piarc.org.

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