Towards Net Zero

A Decarbonisation Roadmap for the Asphalt Industry

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Towards the decarbonisation of Europe

After the signature of the Kyoto Protocol in 1997 and the subsequent Paris Agreement in 2015, the signatory states established common action in climate protection and legally binding obligations for limits and reductions, especially in Greenhouse Gas (GHG) emissions. The ratified countries set their own reduction targets, whereby a review and strengthening of the climate protection efforts was to take place every 5 years.

In Europe, initiatives, such as the European Green Deal (started in 2019) [1] and the major legislative overhaul so-called Fit for 55 (launched in 2021) came against the backdrop of the Paris Agreement and set out an ambitious plan, which would change the political agendas of all Member States through the establishment of 2 key milestones: **the reduction of 55% of GHG emissions by 2030 and the carbon-neutrality by 2050** (taking the emissions in 1990 as the reference value).

The transport sector has been identified as one of the most GHG producing sectors, where **roads support the transport of 81% of passengers and 73% of inland freight in Europe.**

Maintaining the road surfaces in good condition and the use of low rolling resistance solutions have been proved to improve vehicles' energy efficiency and thus consequent emissions.

In addition, as **more than 90% of the European roads are surfaced with asphalt**, the European asphalt industry has the potential to become a key tool in the decarbonisation process of Europe and is already active in various fields to target a climate-neutral future.

For this, it is important that road construction and maintenance operations are done by using materials and techniques that require the minimum amount of emissions at every stage of the asphalt life cycle.

This publication aims to show the solutions that are likely to contribute to reaching these objectives, and a strategic roadmap to achieve them in the required time.

Asphalt for road construction and maintenance

Asphalt is a mixture of aggregates, binder, filler and additives, used for constructing and maintaining roads and other paved and trafficked areas, for example: parking areas, railway tracks, ports, airfield runways, bicycle lanes, footways and also play and sport areas.

Aggregates used for asphalt mixtures are normally crushed rock, sand or gravel. In order to bind the aggregates into a cohesive mixture, a binder (most commonly crude oil-based bitumen) is used.

There are a wide range of asphalt solutions on the market that allow engineers to select the optimum solution for each situation.

Asphalt is easy to construct, maintain and repair, and when it reaches the end of its service life, it can be 100% re-used as "asphalt into new asphalt" or recycled, e.g. as a granular material for other civil engineering applications.

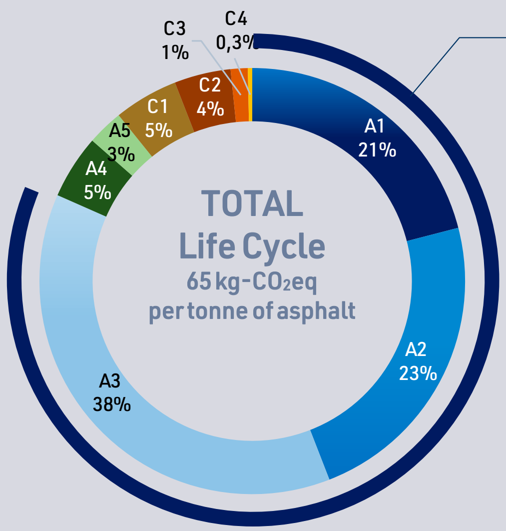
2022 data [2] indicates that in Europe, approximately 70-75% of the reclaimed asphalt available to the industry is re-used, 20-25% is recycled and less than 5% is used on other applications or put to landfill. These figures place asphalt at the front row of circularity among other construction materials.

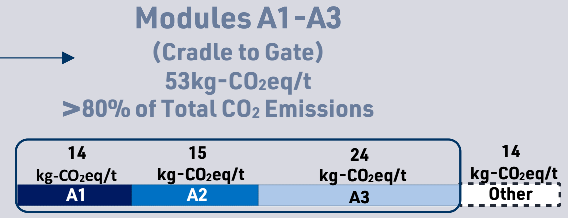
'Carbon' Emissions of Asphalt

The carbon equivalent (CO_2eq) emissions associated with asphalt through the stages of its life cycle, not including the service stage, according to the Modules of the EPD methodology (Standard EN 15804+A2), are illustrated in the figure below.

In 2022 EAPA sent out a questionnaire to its national members with the aim of defining an "average" or "representative" asphalt mix in their respective countries. This covered the current scope of production and paving, which can be used as an indicative baseline in Europe to inform the decarbonisation impact of different technologies.

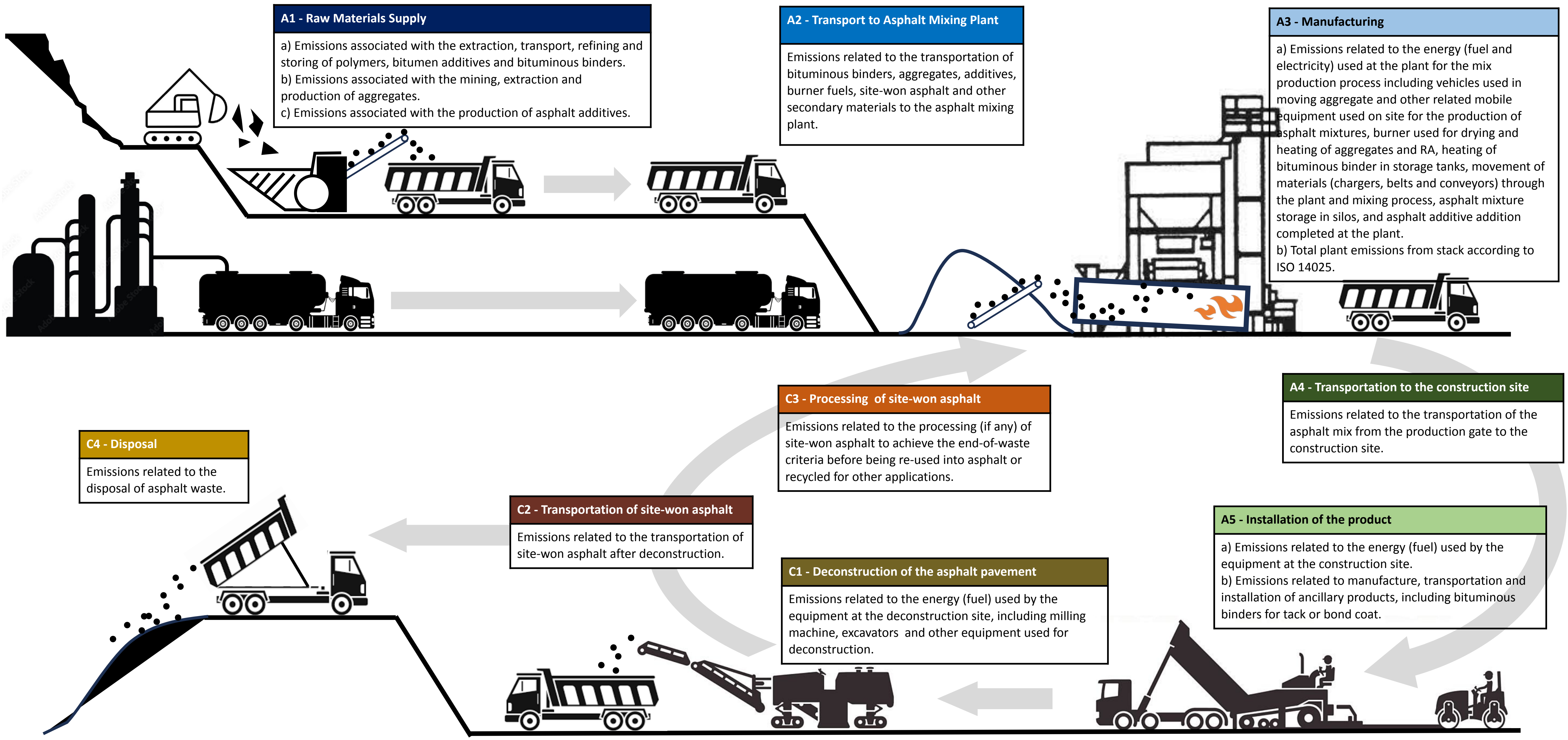
By using the EPD generator LCA.no, a Life Cycle Assessment (LCA) was performed. Calculations showed that the production of 1 tonne of a reference asphalt results in the emission of 65 kg of CO_2eq during its whole life cycle, 53 kg of CO_2eq if emissions are only considered until the product leaves the production plant (cradle-to-gate). Extrapolating to 213 Mt of total asphalt production in the EU-27 in 2022 [2], the asphalt paving industry would account for 14 Mt of CO_2eq per year, around 0,35% of total emissions [3] in the EU.





The embodied carbon emissions of the raw materials represent around 21% of the total, 23%* to their transport to the asphalt plant, and those during the manufacturing process around 38%. Therefore, more than 80% of the emissions associated with the whole life cycle of asphalt are generated before the material leaves the asphalt plant. For this reason, the asphalt sector has been actively developing solutions that can help to reduce carbon emissions in those stages.

**Results of A2 and A4 are particularly sensitive to country/project circumstances, varying between 7%-25%*



Impact reduction potential of different technologies

Low-temperature manufacturing

-1,1% Emissions by 2030 → -2,2% Emissions by 2050

Traditional asphalt manufacturing processes involve heating aggregates and bitumen to temperatures around 160ºC, consuming significant amounts of energy and releasing substantial CO_2eq emissions. By adopting lower-temperature techniques (such as foaming or the use of Warm Mix additives), the manufacturing emissions can be lowered. Additionally, lower manufacturing temperatures may lead to extended asphalt pavement lifespan (as the binder is initially less 'aged'), further reducing the need for frequent resurfacing and additional emissions from maintenance activities. For calculations, it was considered that the current level of implementation of 4,8% could increase to 50% by 2030 and 100% by 2050.

Decarbonised fuels at the plant

-7,5% Emissions by 2030 → -14,1% Emissions by 2050

Transitioning from carbon-intensive fossil fuels at the asphalt plant to low- carbon or carbon-neutral alternatives plays a crucial role. This involves replacing traditional fossil fuel sources like coal, diesel and gas with solutions like wood pellets and fully-renewable energy sources, such as wind, solar, hydro, geothermal, or bioenergy, as well as carbon-neutral solutions, such as hydrogen power supply systems. For calculations, it was considered that in 2030, only gas (LNG), bio-fuels and electricity (either applied directly or in the production of fuels like hydrogen) will be used, eliminating other fuels like coal and diesel. In the 2050 scenario, gas is eliminated as well, remaining only green energy sources.

Efficient bitumen tanks

-1,2% Emissions by 2030 → -1,4% Emissions by 2050

Bitumen heating in storage tanks is an energy intensive process that can be environmentally improved by switching from traditional fuels, such as diesel to natural gas or, even better, to electric heating equipment. For calculations, it was considered that in 2030 only electric and gas heating will be used (no diesel), while for 2050, it was considered that only electric heating will be used.

Circularity

-5,6% Emissions by 2030 → -12,3% Emissions by 2050

Reusing asphalt involves incorporating reclaimed asphalt from existing pavements into new mixtures, thus reducing the demand for virgin materials. This practice conserves natural resources, decreases emissions from transportation of raw materials, and cuts down emissions related to waste disposal. For calculations, it was considered that the current average content of 12,8% could increase to 30% by 2030 and 50% by 2050.

Moisture in aggregates

-4,9% Emissions by 2030 → -4,9% Emissions by 2050

Protecting aggregate and RA stockpiles from rain can help to reduce moisture content and, consequently, the energy needed to dry such materials. Scientific literature shows that every 1% reduction in moisture content leads to a reduction in drying energy consumption of around 8 kWh. For the calculations, a 2% moisture reduction was assumed by 2030, as this is something that can be achieved relatively easy.

Energy Efficient asphalt plants

-0,5% Emissions by 2030 → -1,1% Emissions by 2050

Carbon emissions from asphalt plants can be reduced by implementing energy-efficient technologies, such as advanced burner systems, heat recovery, emission control technologies, automated control systems and mix storage systems to minimise inefficient plant starts and stops. In addition, advanced Asphalt 4.0 technologies and digital tools, such as AI will help to optimise the efficiency of the manufacturing process and minimise energy demands. Continued research and innovation can drive ongoing improvements in energy efficiency and emissions reduction. Due to the short time remaining until 2030, this benefit will be more noticeable for the year 2050. For calculations, in 2050, a 50% reduction in energy consumption was considered.

Low-Carbon binders

-N/A Emissions by 2030 → -5,2% Emissions by 2050

Replacing oil-based bitumen with alternative binders minimises the environmental impact of extracting, transporting and refining crude oil for bitumen production. In addition, some may contain biogenic carbon, which accounts as a "carbon credit", compensating for other emissions. Currently, practical implementation is limited to experimental work but numerous developments are being investigated by the Industry and Academia. In the future, this could even represent conventional oil-based binders manufactured in a decarbonised way. For the calculations in this study, the specific EPD of a commercial lignin-based bio-component was considered. Nevertheless, the goal is to represent the effect of not only this specific solution but also others based on other biogenic sources. The assumed replacement of conventional binder by these materials was zero by 2030 and 10% by 2050.

Site efficiency

-N/A Emissions by 2030 → -4,0% Emissions by2050

Carbon emissions from machinery at the jobsite can be reduced by improving fuel efficiency through advanced engine designs, optimizing operations to minimise idle time and energy consumption, adopting innovations in materials handling processes, such as optimized conveyor systems, and embracing alternative fuels, electric and hybrid technologies. Due to the short time remaining until 2030, this benefit has not been considered for this year. For calculations, in 2050, 80% reduction in emissions was assumed.

Decarbonised transport of materials

-N/A Emissions by 2030 → -11,4% Emissions by2050

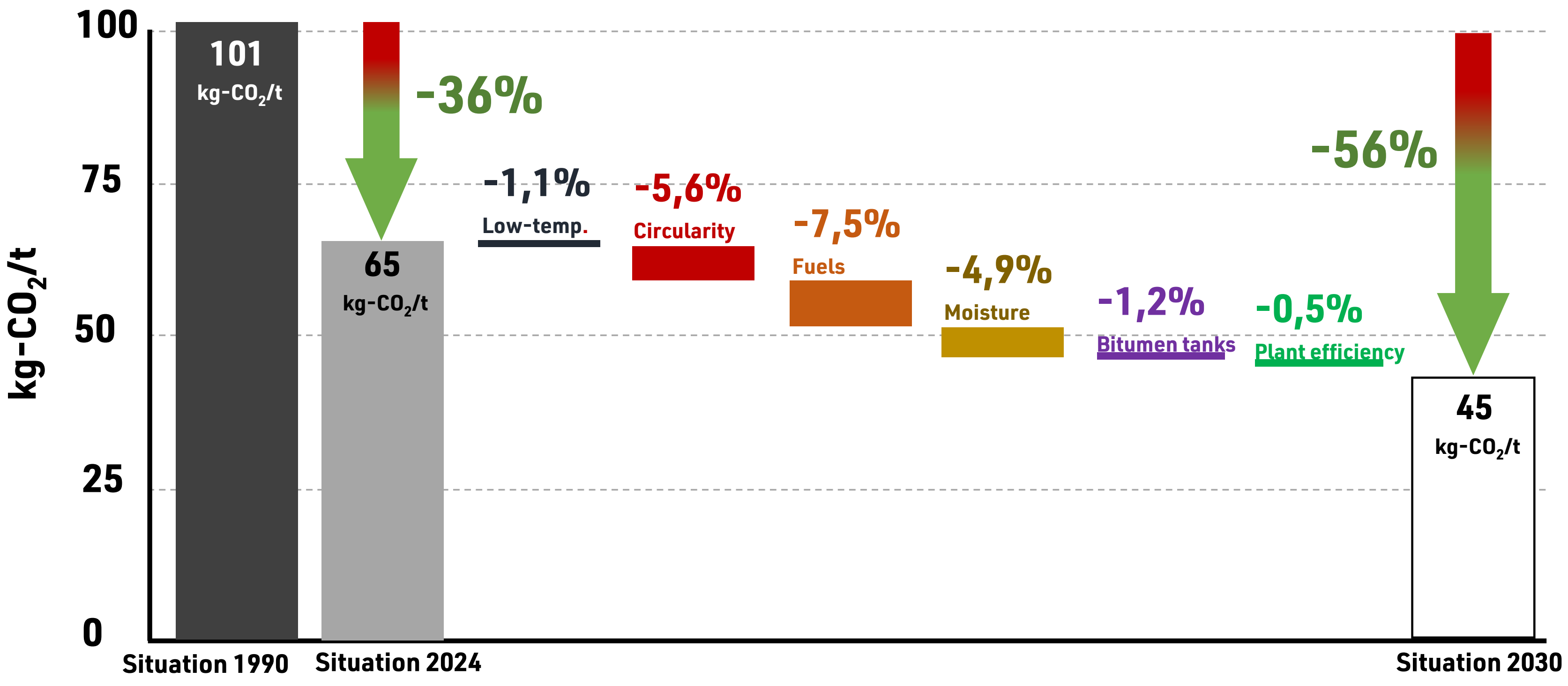
Reductions in greenhouse gas emissions can be achieved by implementing measures to decarbonise the transport of raw materials, asphalt mixtures (after production to the job site) and site-won asphalt (after deconstruction). This can be accomplished through the adoption of electric or hybrid vehicles, utilizing alternative fuels like biofuels or hydrogen, and optimizing logistics to reduce empty miles and improve route planning. Advances in this realm continue to be achieved by the automotive industry. Nevertheless, due to the short time remaining until 2030, this benefit has not been considered for this year. For calculations, in 2050, 80% reduction in emissions from transport was assumed.

Other

After applying the previous strategies, less than 10% of CO_2eq emissions remain. These are expected to be addressed by other future developments not included in the scope of this study. Some examples are the use of Half-Warm and Cold Mix Asphalt, the decarbonisation of grid electricity generation, the decarbonisation of raw materials production (e.g. bitumen and aggregates via transferable technologies) or the implementation of carbon capture and storage systems. It may also be possible to permit carbon offsetting strategies, when best available techniques do not result in a net zero outcome.

A holistic strategy

Achieving the decarbonisation objectives requires the implementation of a holistic strategy, with the main 2 milestones in 2030 and 2050.



›› 2030

The targets for reduction are established by taking as reference the values in 1990. Unfortunately, there is little data available about the situation at that time. The 1990 scenario was created based on certain assumptions, while leaving the rest of parameters unmodified, which is likely to be a conservative scenario with actual emissions being higher than those modelled for 1990. Some of the adopted assumptions were 0% of RA content, 0% of WMA production, 52% higher consumption for transportation and a fuels distribution of 30% coal powder and 70% heavy fuel-oil. With these assumptions, the **calculated CO_2eq emissions in 1990 were 101 kg-CO_2eq/t** (67 kg-CO_2eq/t if only the modules A1-A3 are considered).

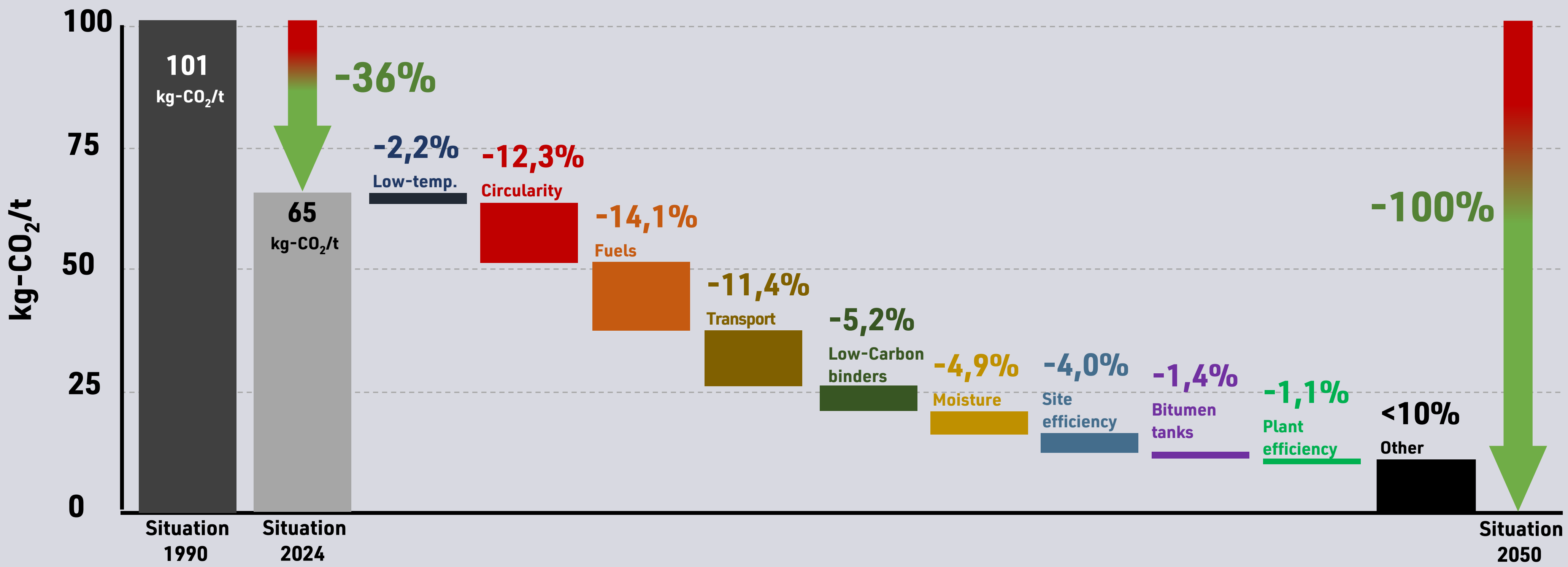
With the solutions and level of implementation described above for the 2030 Scenario, **the calculated CO_2eq emissions result is 45 kg-CO_2eq/t**. If only the modules A1-A3 are considered (cradle to gate approach) the emissions are 33 kg-CO_2eq/t. This means a reduction of 55,6% compared to the baseline of 1990, greater than the European objective of 55%.

›› 2050

With the solutions and level of implementation described for the 2050 Scenario the calculated CO_2eq emissions are 9,6 kg-CO_2eq/t, which represents more than 90% reduction compared to 1990. If only the modules A1-A3 are considered (cradle to gate approach) the emissions are 7 kg-CO_2eq/t.

The remaining <10%, necessary to meet the European objective of Carbon Neutrality is expected to be covered by other future developments not included in the scope of the study (e.g. the decarbonisation of electricity production or the implementation of carbon capture and storage systems).

The scale of benefits and broad implementation of solutions are variable and may consequentially result in net-zero emissions in any case e.g. zero-carbon fuels, transportation and binders.



A Roadmap for the Asphalt Paving Industry

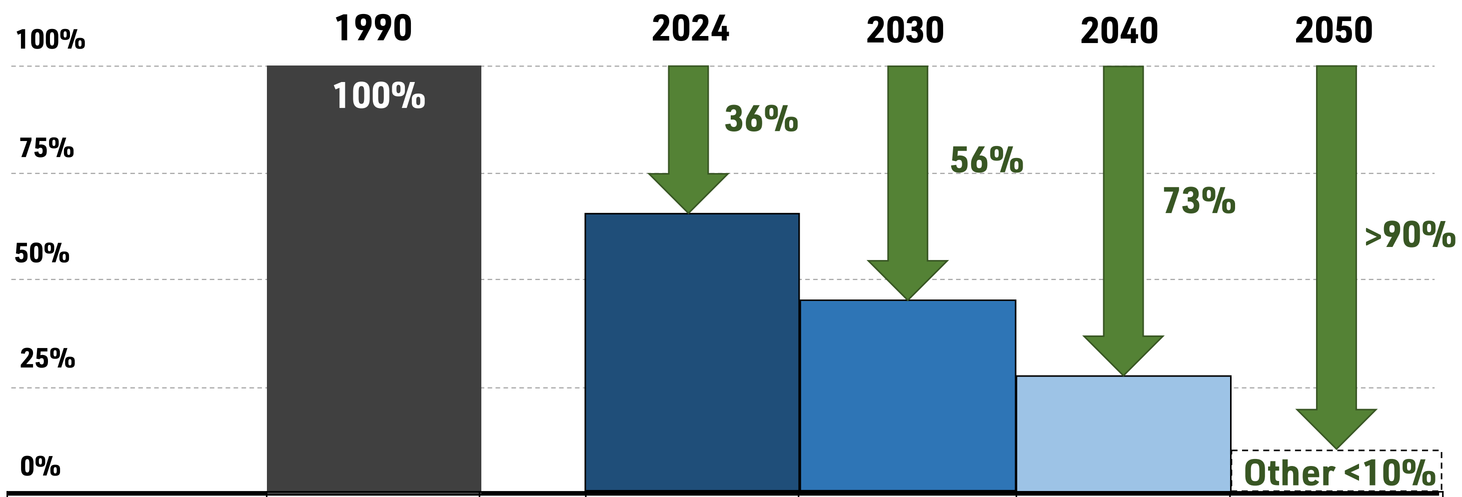
Based on the reduction scenarios, a clear strategy and roadmap of actions has been developed.

It is important to mention that not all countries will start from the same position and not all will have the same opportunities to fully develop all the potential that certain technologies might offer.

For these reasons, the roadmap illustrated below aims to:

1. Show stakeholders and society in general that, even with current and near-market technologies, it has been possible to derive a strategy that will allow the asphalt paving sector to meet the European decarbonisation objectives.
2. Show industry a probabilistic strategy that can be used for comparison with their current situation and to inform future investments.

This roadmap should not be considered as a fixed strategy, as EAPA is committed to periodically review and revise it over the coming years.



	1990	2024	2030	2040	2050
Binder substitution	0%	0%	~0%	5%	10%
% WMA production	0%	4,8%	50%	75%	100%
Average RA content	~0%	13,2%	30%	45%	50%
Fuels	Coal, heavy fuel-oil	Mix (all)	Gas, bio, hydrogen	Gas, bio, hydrogen	Bio, hydrogen
Moisture reduction	0%	~0%	2%	2%	2%
Binder heating	Heavy fuel-oil	Fuel-oil, gas, electric	Gas, electric	Electric	Electric
Transport emissions	152%	100% (reference)	~100%	60%	20%
Plant consumption	~100%	100% (reference)	~100%	75%	50%
Job-site emissions	~100%	100% (reference)	~100%	60%	20%

Beyond Net Zero

Warm Mix Asphalt (WMA)

When compared with other techniques, the impact of Warm Mix Asphalts (WMA) may seem of little importance (1,1% reduction by 2030 and 2,2% by 2050), it is important to highlight that its use can also lead to other benefits:

1. Enhanced worker health and safety by reducing potential exposure to high temperatures and fumes during paving operations. As a rule of thumb every 12°C reduction in temperature reduces fumes 50%.
2. Reductions in already regulated emissions, such as sulphur dioxide (SO_2), volatile organic compounds (VOC), carbon monoxide (CO), nitrous oxides (NOx) and particulate matter release [4].
3. Reduced energy consumption may translate into a reduced dependency on fuel supply from outside Europe.
4. Less short-term ageing of the bitumen during manufacture. This may lead to an improved pavement service life, reducing the frequency of repair and replacement interventions.
5. Reduced thermal stress on the plant components resulting in less wear and replacement.
6. Full compatibility with the use of Reclaimed Asphalt.

Impacts on the use stage

In this study, the impacts during the service life (Modules B according to the Standard EN 15804+A2) were not taken into account, as they depend on specific circumstances of each project, e.g. pavement designs, traffic levels, climate conditions or maintenance budgets and strategies.

However, it is important to note that asphalt types, mix designs and technologies aimed at improving the quality and performance of the final product can contribute to a longer durability, fewer maintenance interventions and consequently, lower whole life emissions.

Additional solutions, which could not be taken into account for the calculations were the use of temperature control during production, vehicles designed to reduce temperature segregation of asphalt during transportation and installation, and logistic digital tools to minimise the time between production and site-installation.

Emissions from the transport sector (road users)

Although this effect is not directly allocated to the life cycle of asphalt or to the asphalt industry, it is important to consider that the road pavement surface can directly influence the fuel consumption of vehicles through the rolling resistance between the road and tyres riding over it. Various aspects of the quality and condition of the road will influence rolling resistance: evenness, rutting, potholes and deteriorated joints. Low rolling resistance asphalt in surface course layers can reduce fuel emissions by around 1-2%.

In addition, scientific studies [5-8] have shown that proper maintenance to replace pavement surfaces that show "bad" or under-performing surface conditions by smooth road surfaces with "good" properties would lead to fuel use reductions and lower GHG emissions. This means that an improvement of 5% in fuel economy applied to just one third of the road network of Europe by 2030 could lead to annual savings of 14 million tonnes of CO^2eq, or the equivalent to removing the emissions associated with 3 million cars. Alternatively, a well-maintained surface could also add range to electric vehicles and add to their viability.

This would be only one of many potential benefits, including reductions in traffic noise and travel time while increasing driving comfort, with savings in vehicle maintenance costs. Roads in good condition should not be left to deteriorate to a condition where they have negative environmental, societal and economic impacts.

A collaborative responsibility

EU road infrastructure is one of the most important of all public assets, estimated to consist of 5.5 million km with value of over 8,000 billion € [9]. They enable free movement of the vast majority of goods and people across the continent and beyond. Carbon-neutral, sustainable, innovative, efficient and of course safe, construction and maintenance of these valuable assets needs to be stimulated and supported to ensure that their past cost, current value and future worth are not compromised.

This document outlines a roadmap with key milestones for the asphalt sector to meet the emission objectives of the current European policy, in time and with the final goal of becoming Carbon-Neutral by 2050.

Reaching each of the milestones on this path, while maintaining the competitiveness of the asphalt sector will require significant long-term strategies and synergies. These are not only between industry and direct stakeholders of the paving sector (such as material suppliers, Road Administrations, Governments and Academia), but between the asphalt sector and others, such as the automotive and energy sectors.

The asphalt industry has experience with some technologies that will need to be boosted beyond current limits (e.g. higher re-use of reclaimed asphalt or the implementation of WMA techniques). Other technologies, such as the use of carbon-neutral energy sources at the asphalt plant or the replacement of conventional bitumens by alternative binders are still at a very early stage. In addition, some necessary external enablers, such as the decarbonisation of the transport sector and of electricity production, are beyond the efforts of the asphalt industry itself.

For all these reasons, underpinning such a long-term strategy relies on supporting strong developments and adaptations by the industry, aligned investments (private and public), innovative research programmes, enabling and flexible specifications and standards, and the commitment of Administrations to use the available technologies with shared risks. In other words, a holistic approach based on cumulative intersectoral synergies and which goes beyond the efforts of the asphalt industry alone must be embraced.

EAPA urges Governments and Road Authorities to:

Push for, permit and incentivise sustainable solutions. To stimulate demand for the use of low-carbon solutions in road construction and maintenance, which optimise the criteria of sustainability, circular economy, eco-design and quality. Enhance effective and timely maintenance strategies and funding.

Underpin the Circular Economy. To set up regulatory plans, in which "asphalt" is never considered as a "waste" by establishing reasonable end-of-waste criteria for site-won asphalt. Better enable the use of deconstructed asphalt as a "by-product" or "secondary raw material" in order to help ensure that site-won asphalt is re-used back into asphalt mixtures or, at least, recycled for other applications.

Enable the use of new technologies. To exploit innovations to enhance road asset management and operation.

Adopt Green Public Procurement: Establishment of Green Public Procurement initiatives, based on Environmental Product Declarations (EPD), which allow fair comparisons among products and suppliers and favour proposals with lower whole life environmental impact, rather than forcing prescribed solutions. This in conjunction with Most Economically Advantageous Contracts which enables innovative, rather than the lowest initial cost, solutions in tenders, with reasonable shared risk.

Boost Research & Developement: To set up balanced R&D Programmes developed and steered collaboratively by industry and road owners/operators with a focus on real needs, with reduced duplication of effort across the EU and to deliver real-life solutions in real projects. Research on topics, such as increasing RA content in asphalt mixes, low-temperature production, large-scale bio-binders production, zero-emissions transport or zero-emissions energy sources for asphalt plants (e.g. hydrogen), may help to more rapidly achieve decarbonisation objectives.

EAPA

EAPA urges the Asphalt Paving Industry to:

Continue product development: To optimise asphalt mixture designs for performance, maximum service life with minimum maintenance and minimum environmental impact.

Optimise circular production: To optimise the processing and handling of the RA to maximise its re-use. Also to develop asphalt plants and mix designs to maximise RA content in new mixes while ensuring that the mixes will be also re-usable and recyclable in the future, when they reach the end of their service life.

Undertake process development: To adapt production plants, as well as transport and construction equipment to undertake advanced manufacturing processes with optimised energy efficiency. The high-quality execution of mix manufacturing, transport and on-site construction operations can also create benefits for pavement performance and durability. Hence, special care must be put on these operations over the whole process, including RA milling and processing, storage, mixture production, paving and compaction.

Adopt Asphalt 4.0: To embrace the digital transformation of the asphalt paving industry. Digitally enabled technologies can help push forward the efficiency, productivity and sustainability of the industrial processes along the whole value chain.

Drive standardisation: To engage with stakeholders of the paving sector to dynamically develop or adapt standards to enable the use of low-carbon materials and technologies.

EAPA urges other sectors external to the Asphalt Paving Industry to:

Supply carbon-neutral raw materials: To develop alternative raw materials for asphalt production, which are produced in a carbon-neutral way, but do not compromise workers health and safety, asphalt performance, as well as circularity at the end of service life [10].

Enable green energy sources: To develop and maximise the capacity and availability of carbon-neutral and renewable energy sources, to be used by all industries.

Develop a decarbonised automotive industry: To develop carbon-neutral solutions for mobile plant and heavy-duty vehicles, used in the transport and processing of raw materials, reclaimed asphalt and the final asphalt mix.

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