"Use Phase" Environmentally Beneficial Paving Additives

White Knights for EPDs and ESG

The recent **"Climate Challenge"** pronouncements from the **Federal Highway Administration (FHWA)**[1] all but ensure that **Environmental Product Declarations (EPDs)** are the future for the paving construction industry as trillions in transportation industry funding the next decade will be dispersed based upon EPD compliance and forthcoming formulized emission reduction goals for paving materials, construction, and **all** road system "use phase" impacts.

Use phase technologies or market-based carbon instruments may be the only viable solutions.

In practice, many transportation authorities making progress on decarbonization are adopting a combination of approaches to include both establishment of target dates for reducing materials and construction emissions directly (EPDs will serve as the "credentialing" function for manufacturers and contractors) as well as purchasing emission offsets ("credits") where such statutory reductions are simply not possible.

We believe both will be necessary in the transportation sector to reach near-term reduction goals but will fall short of what will be necessary long-term given well established intractable paving product design and transportation type emission reduction limitations.

Environmental sustainability has not always been top of mind for transportation professionals focused primarily and necessarily on building and maintaining high quality road systems and airports to simply get goods and people from point A to point B. That now is changing.

As supply chains evolve into **environmental value chains** as well, the paving industry's ***carbon footprint*** will be assessed beyond product manufacturing and construction to mirror the economic value chain. Narrow sustainability initiatives not only will be inadequate to make a difference in overall transportation sector emissions, but they will also not be acceptable under current and proposed compliance frameworks.

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[1] FHWA Climate Challenge – Quantifying Emissions of Sustainable Pavements, www.fhwa.dot.gov/infrastructure/climatechallenge/.

There is, however, a larger related opportunity for the paving industry that not only can lead to *net zero*, but even turn roadways into carbon assets (net negative). This is part one of that discussion.

Use phase (EPD) and **scope 3 (ESG)** emissions make up the vast majority of systematic emissions in transportation, meaning they may technically fall outside a reporting subsector such as the paving construction industry's direct control. But this will not reduce regulatory accountability, unfortunately. Transportation industry emissions accounting is complex and hence daunting. But all participants in the economic value chain will be held to account.

Also known as **value chain emissions**, use phase and scope 3 encompasses activities both upstream and downstream from a subsector's direct operations. They are a direct consequence of decisions made. In the case of paving materials, processing, and construction, most scope 3 emissions are not an unintended consequence. They are a byproduct of the very reason for the industry itself - traffic.

Materials substitutions are only making slow developmental progress and materials recycling faces realizable carbon savings hurdles, so they are unlikely to have enough impact.[2] Use phase technologies[3] and market-based carbon (offsetting) instruments (MBI)[4] may be the only viable solutions to this growing economic-environmental disequilibrium in paving construction and the broader transportation industry.

The **National Asphalt Pavement Association (NAPA)** has calculated a modest net benefit of **recycled asphalt (RAP)**, concluding that for every 1% increase in RAP (restricted to a 20% RAP content carbon break-even before LCA impacted)[5] nationwide, would equate to just 0.01% vehicle equivalents.[6] That is not going to *move the needle* in overall transportation sector emissions.

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[2] National Asphalt Pavement Association (NAPA): *The Road Forward, A Vision for Net Zero Emissions for the Asphalt Pavement Industry*, www.asphaltpavement.org/climate.

[3] **use phase technologies** are product enhancements or complements that provide polluters with environmental offsets to reduce or eliminate their own product environmental externalities e.g., carbon emissions.

[4] In environmental law and policy, **MBIs** are market-based financial instruments that provide polluters with environmental offsets to reduce or eliminate their own product environmental externalities e.g., carbon emissions.

[5] Aurangzeb Q et al, *Hybrid life cycle assessment for asphalt mixtures with high RAP content*, Dept. of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, 2014.

[6] NAPA: *The Road Forward*.

Warm Mix Asphalt (WMA) is a technique to simply reduce the energy used in asphalt manufacturing. 10°F to 40°F lower temperatures typically can be achieved, rendering, at scale, *cradle-to-gate* **carbon reductions that can range up to 2%**.[7]

Nineteen percent (19%) of asphalt mixes produced in 2019 used WMA technologies for energy reductions.[8] The estimated GHG emissions reductions ranged 0.05 to 0.21 million tons or less than one percent of industry total emissions.[9]

NAPA identifies the coming challenges our industry faces:

"To achieve net zero in the production of asphalt mixtures, carbon offsets will be necessary." – The Road Forward

As of 2019, domestic ***cradle-to-gate*** or **production stage** emissions from **asphalt concrete (AC)** was ~22 million metric tons (MMt)[10] of CO_2e, up 16% from a decade earlier. *Cradle-to-gate* emissions intensity remained flat, however, indicating the production of AC has been neither improving nor deteriorating in relative (to economic growth) emissions.[11]

In other words, the industry has been stagnant on GHG emissions from mix design, materials, and transport in recent years despite more focus on **warm mix asphalt (WMA)** and (RAP).

Though AC production emissions are quite small relative to overall U.S. GHG emissions, more than two-thirds of production stage emissions come from asphalt binder.[12] This will continue to be a hurdle for the asphalt industry as it is exceedingly difficult to reduce **asphalt concrete binder (AB)** sourcing and production emissions without compromising both quality and durability.

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[7] Ingevity Corporation; FHWA; NAPA.

[8] NAPA.

[9] NAPA.

[10] A metric ton (Mt) is 1000 kilograms (kg) vs. a ton (t) is 2000 pounds (lb.); 1 kg = 0.45 lbs.

[11] Emissions intensity is the volume of emissions per unit of gross domestic product (GDP).

[12] NAPA.

Adding construction stage (paving) or ***cradle-to-pave***; life-cycle maintenance; and some use phase impacts such as pavement vehicle interactions (PVI)[13] double AC emissions (table).[14]

AC GHG Emissions per CLM *Cradle-to-Grave*[15]

Production	1,000
Construction	800
Maintenance	500
PVI	1,000
Emissivity	400
EOL	50
Total	3,750

Source: BlackwallPartners LLC compilation

Throughout the balance of 2022 and 2023, state DOTs have launched 80-20 FHWA matching projects utilizing EPDs under the **Investment in Infrastructure and Jobs Act (IIJA)**. By 2024, the states are to have completed these trial projects ("showcases") and be ready to work with the FHWA on **full implementation time frames**.

The paving industry needs to get out in front of this. As practitioners, we are the experts. Are we really going to let politicians, academics, and activists decide this?

EPDs will no longer just be a way to differentiate products and practices in pavement construction and maintenance soon. They will be rolled-out as mandatory starting at the state DOT level. Many local agencies follow their state DOT guidelines.

[13] Pavement Vehicle Interactions (PVI) include roughness impacts on fuel efficiency and both tire-wear and brake-pad wear.

[14] FHWA.

[15] BlackwallPartners LLC; FHWA; MIT CSHub; NAPA; National Center for Pavement Preservation (NCPP); et al; 25,000 AADT road.

Alternative mix design; energy sourcing; and transportation type are proving more difficult to scale or even afford financially and environmentally than any of us hoped.[16] [17]

As outlined, there likely will not be emissions opportunities in raw materials, mix design, processing, and paving to more than just fractionally improve overall emission loads from paving as the environmental impacts from the roadway microenvironment (ME) are not limited to the materials and the paving process.

Transportation system related carbon including both imbedded and systematic emissions approximate one-third of all emissions. As the paving industry necessarily faces carbon reduction mandates, extended boundary exposure creates both potential regulatory and financial risk as well as opportunity to differentiate.

Because it is such a broad category, use phase and scope 3 emission sources often make up the majority of an organization or subsector's GHG emissions. But they also typically offer the **greatest opportunities** for emissions.

Here is what existing paving additives bring to environmental compliance:

- Various ***in-service*** **binder recovery and improvement** strategies e.g., rejuvenators to *stretch out* repaving cycles to directly cut embodied or scope 1 emissions for agencies, asphalt manufactures, and pavers.
- **Reducing pavement reflectivity and emissivity** with use phase additives to extend pavement lifecycles and mitigate the Urban Heat Island effect (UHI) from roadway "heat sinks."
- Targeting **"ride quality"** or pavement vehicle interactions (PVI) with preservation tools to lower use phase and scope 3 emissions related to improved vehicle fuel efficiency and tire-wear pollution.
- **Photocatalytic pavement** additives using **titanium dioxide (TiO_2)** are designed to be a retrofit technology for existing transportation infrastructure. TiO_2 additions to a pavement wearing course have been proven to materially reduce both vehicular exhaust emissions (CO_2 and NOx) and non-exhaust emissions (NEEs) e.g., tire-wear microplastics (RAMP) that are particulate matter (air quality); greenhouse gas (GHG); and water quality hazards critical to scope 3 emissions compliance in transportation.

[16] Finkler T and Hannon K, *Renewable Energy: Status and Struggles*, Stanford University.

[17] The Wharton School, University of Pennsylvania, *Can the World Run on Renewable Energy?* April 2015.

The best way to express the compliance benefits of existing pavement additives available commercially is to use an example. In this case (table) an asphalt rejuvenator fortified with TiO_2 that both extends service life and offsets scopes 1, 2 & 3 emissions:

AC GHG Removal Breakdown Per CLM Using a TiO2 Fortified Asphalt Rejuvenator

(Mt CO_2e)

	Per Year	10 Year
Vehicle CO_2[18]	**2,600**	**17,160**
Vehicle NOx[19]	**980**	**6,468**
Tailpipe Emissions	**3,580**	**23,628**
Solar Reflectance[20]	**800**	**5,280**
Vehicle RAMP[21]	**250**	**1,650**
Maltene Replacement[22]	**150**	**1,500**
Total	**4,060**	**32,058**

Source: BlackwallPartners LLC

Model Assumptions:
CLM; 260 days
25,000 AADT
90% light vehicle, 10% truck
10-year terminal photocatalytic efficiency 50%

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[18] EPA; Texas A&M Transportation Institute (TTI), International Standard *ISO 22197-1 Test method for air-purification performance of semiconducting photocatalytic materials*.

[19] EPA; 60 Co_2e per Dahlmann K et al, *Quantifying the contributions of individual NOx sources to the trend in ozone radiative forcing*, DLR Institute for Atmospheric Physics, Oberpfaffenhofen, Germany, February 2011.

[20] Texas A&M Transportation Institute (TTI) and Massachusetts Institute of Technology (MIT) – MIT Concrete Sustainability Hub (CSHub): Solar Reflectance Index (SRI) ASTM E1980-11 *Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces*; converted into radiative forcing (RF) or GWP/ CO_2e.

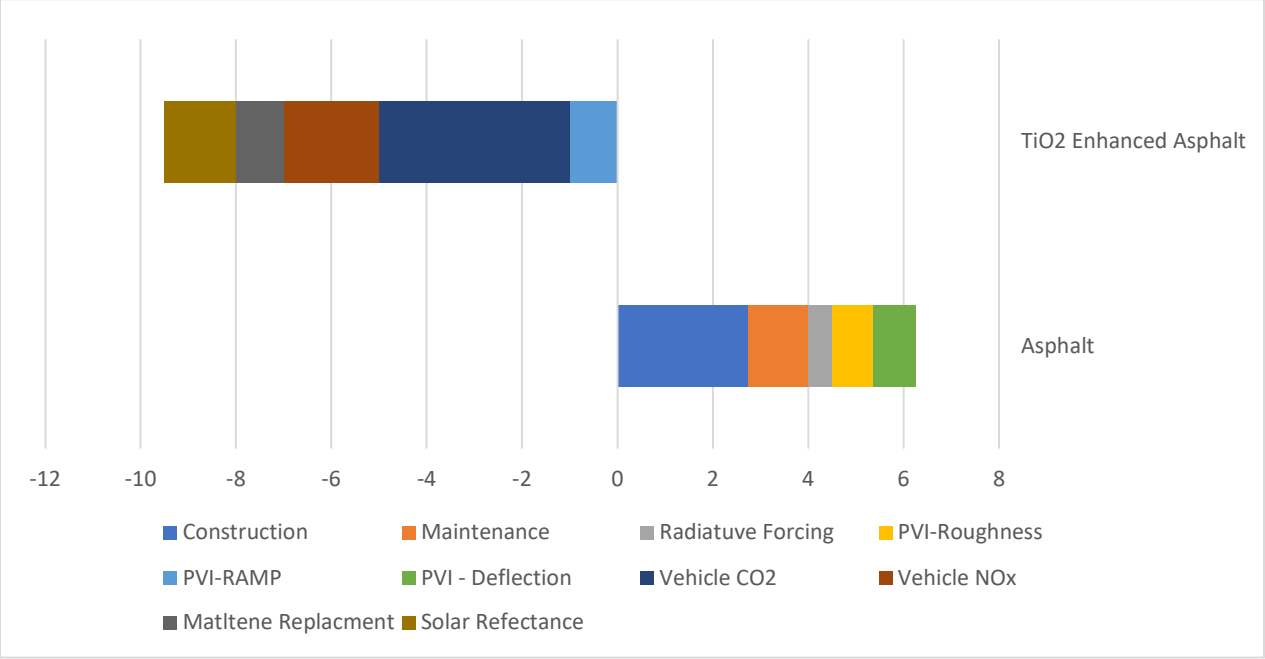
[21] Shen M, Huang W, et al, (Micro)plastic crisis: Un-ignorable contribution to global greenhouse emissions and climate change, May 2020.

[22] A.R.A.1-Ti CO_2e AC abatement; National Center for Pavement Preservation (NCPP); Colas S.A.; Chehovits J and Galehouse L, *Energy Usage and Greenhouse Gas Emissions of Pavement Preservation Processes for Asphalt Pavements, Transportation Research Board*, 2010; Ergon, Inc.; and Multi-year MRT Sustainability Study: Charleston County (SC): Pavement Technology, Inc.; APART.

The TiO_2 addition to an asphalt surface course can more than offset 100% of the embodied carbon (scope 1 and 2 emissions) of the constructed pavement and hence also materially reduce scope 3 emissions as well.

AC GHG "Credits" vs a "Naked" Pavement

(Per CLM Kt CO_2e)



Our world is rapidly moving from emissions inventory reporting to accountability. No firm and no sector will be immune.

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