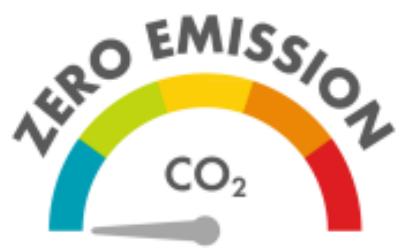


SUSTAINABLE MATERIALS & “CIRCULAR ECONOMY –ROAD INFRA”

Engineering Excellence :
We need to Change the Way we Deliver



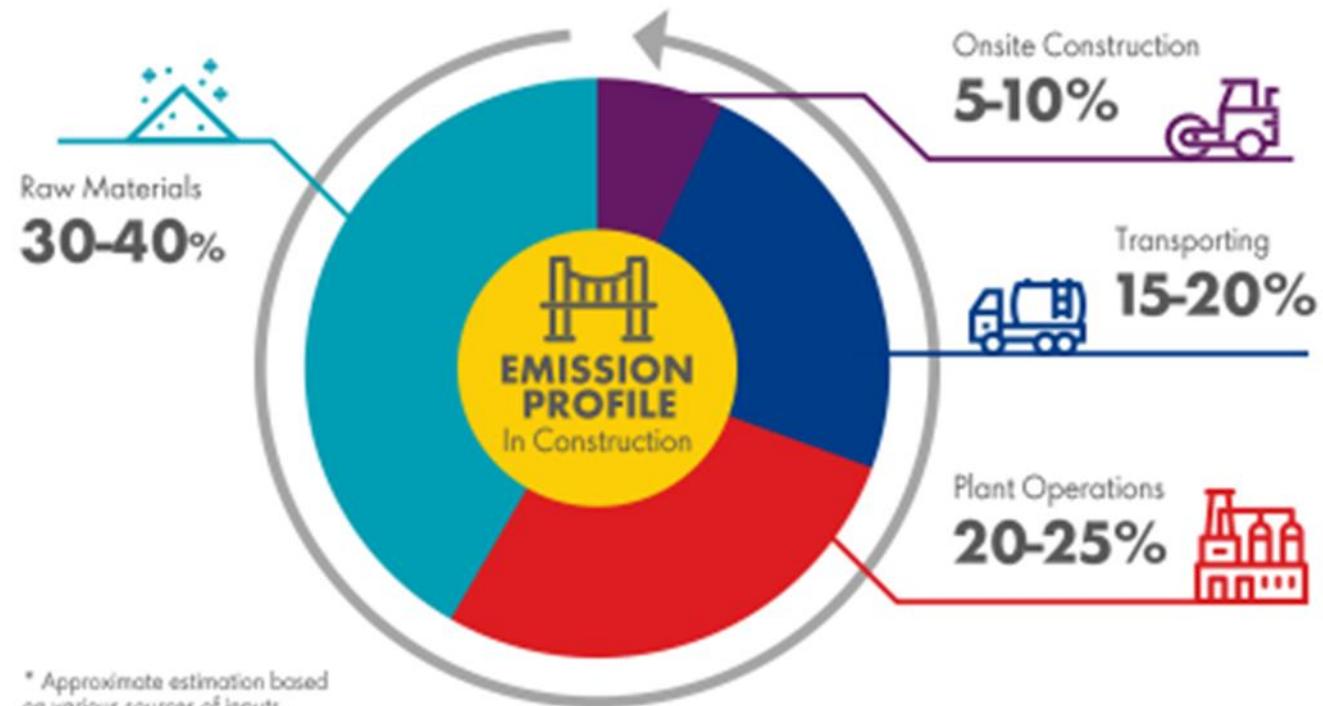
*Dr. Ambika Behl, Sr. Principal Scientist
CSIR-Central Road Research Institute*



India aims to reach net zero by 2070



Net-zero construction requires decarbonisation of...



CIRCULAR ECONOMY IN CONSTRUCTION

Introduction

- Traditional road construction = linear model: take → make → use → dispose
- Circular economy = keep materials in use longer, reduce waste, and minimize environmental impacts
- Road construction has huge potential due to high material volumes and frequent rehabilitation

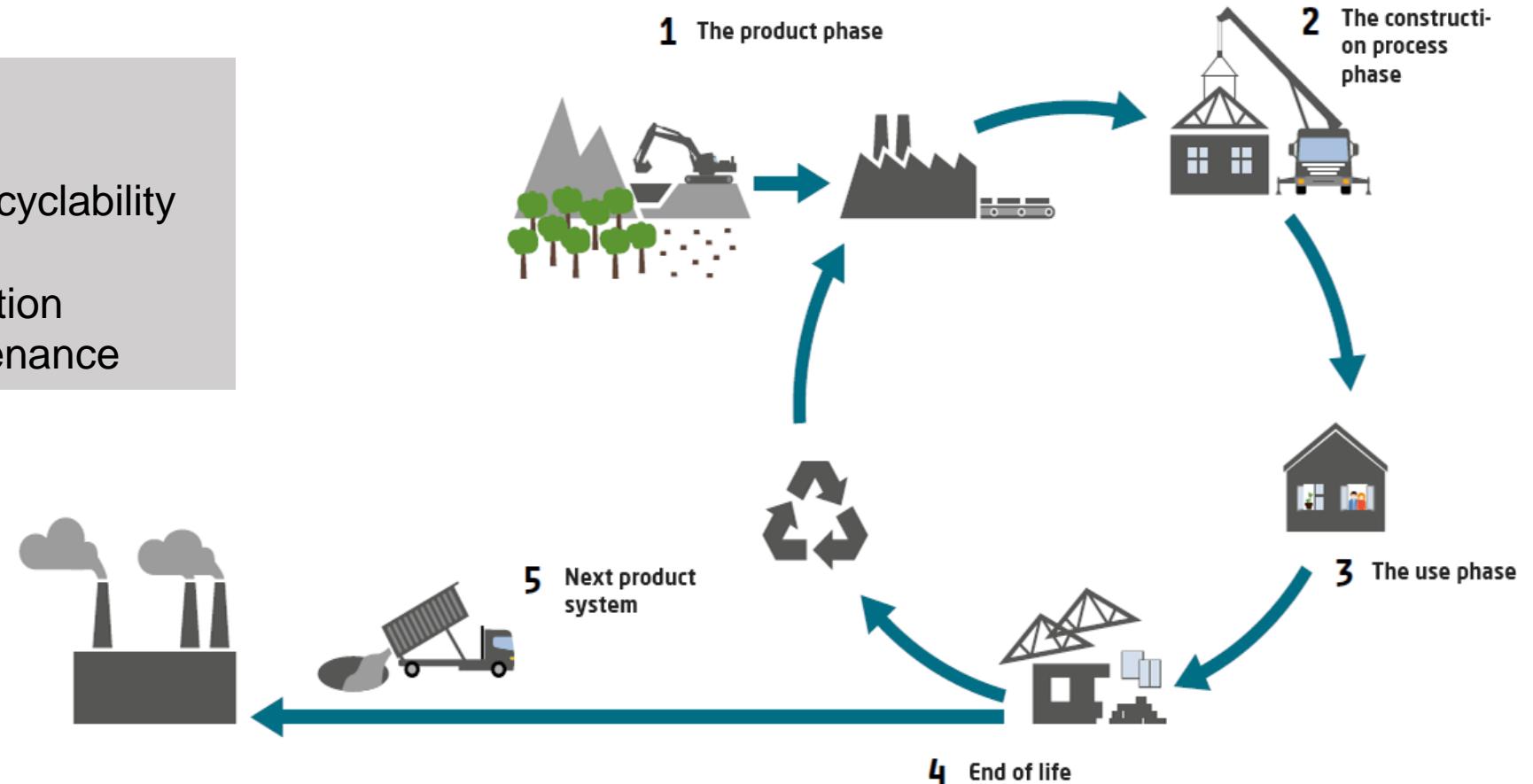


Why Circular Economy?

- Roads consume large amounts of aggregates, asphalt, energy
- Construction and demolition waste is a major waste stream
- Growing climate and sustainability targets demand resource-efficient solutions
- Circularity reduces lifecycle costs and improves durability

Key Principles

- Material Reuse & Recycling
- Design for Longevity and Recyclability
- Reduced Virgin Material Use
- Energy and Emission Reduction
- Digitalization & Smart Maintenance



Circular Processes Across Road Construction

- Life cycle Design → prioritize **recyclability**
- Construction → **minimize waste**, use recycled materials
- Maintenance → in-situ **recycling**, sealing, overlays
- End-of-life → full-depth reclamation and **reprocessing**

Material Reuse & Recycling

Reclaimed Asphalt Pavement (RAP) in new asphalt mixes

Recycled concrete aggregates (RCA) in base layers

Waste materials:

Plastic-modified bitumen, Rubberized asphalt (tires) Glass, slag, fly ash, bio-binders

On-site recycling (in-place recycling)

Reduce Virgin Resource Use

Substituting natural aggregates with recycled ones

Using industrial by-products (slag, fly ash, silica fume)

Increasing RAP content to 60% revising the standards

Bio-based binders from lignin, algae, or waste oils

Digital Tools

BIM for material tracking and design optimization

Sensors and IoT for condition monitoring

Predictive maintenance reduces waste and premature failures

Design for Longevity

Durable materials → fewer rebuilds

Modular pavement layers for easier rehabilitation

Perpetual pavement designs

Asset management based on lifecycle cost analysis

Energy & Emissions Reduction

Warm Mix Asphalt (WMA) → 20–40% lower emissions

Renewable energy in asphalt plants

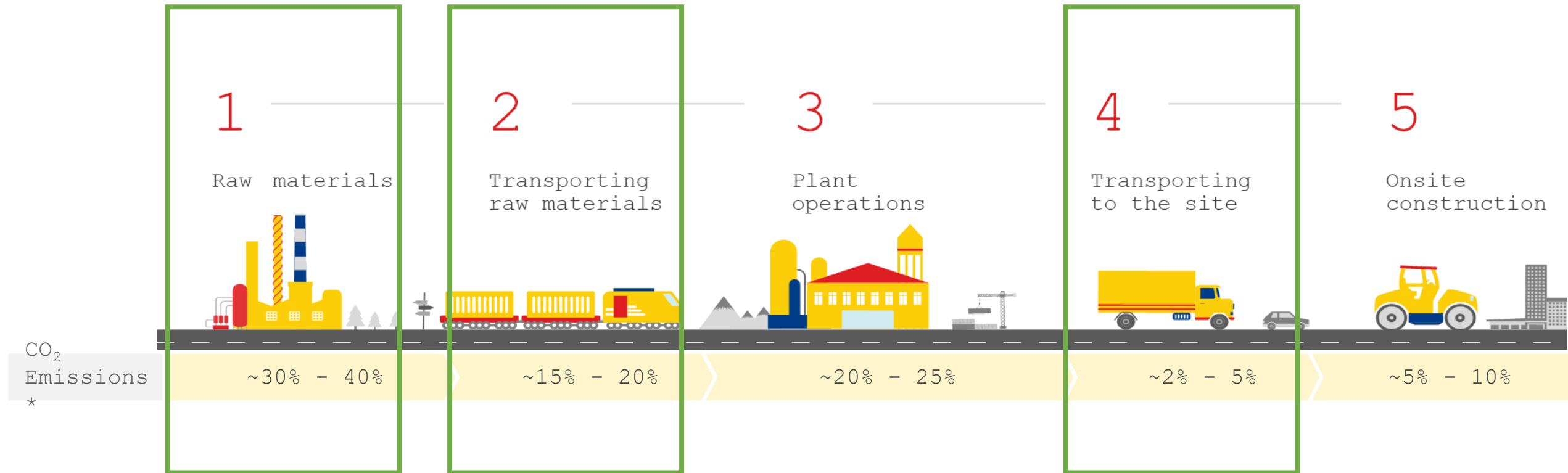
Electrified or hybrid machinery

Optimized transportation logistics to cut fuel use

SUSTAINABLE PAVEMENT CONSTRUCTION PRACTICES

- 1 • Waste Plastic Roads
- 2 • Warm Mix Asphalt
- 3 • Stabilization Technology
- 4 • Recycling of Pavements
- 5 • Modified Binders/ Mixes
- 6 • Use of Marginal/Alternate Materials

THE C METRICS



USE OF RAP REDUCES CARBON

60% RAP SECTION NH-206



The Green Effect - 60% RAP

Material Savings Per 332.1-ton HMA Mix			
Material consumption /savings	DBM		
	With RAP	Without RAP	
Bitumen Used, tonne	7.1	16.6	
Aggregate Used, tonne	137.6	314.5	
RAP used, tonne	187.4		
Savings in Aggregate, tonne		177.2	
Savings in Bitumen, tonne		9.5	
Emission Savings Per 332.1-ton HMA Mix			
Emission saving	DBM		
	With RAP	Without RAP	
Material Embodied Energy, tCO ₂ eq	Emission Bitumen, tCO ₂ eq	3.5	8.1
	Emission Aggregate, tCO ₂ eq	0.8	1.9
	Total, tCO ₂ eq	4.3	10
	Savings, tCO₂eq	5.7	
During construction tCO ₂ eq	Hot Mix Plant, tCO ₂ eq	20.3	22.6
	Savings, tCO₂eq	2.3	

BITUMEN : 57%

AGGREGATE : 56%

CO2: -57%

CO2: -10%

USE OF RAP LEADS TO LOW CARBON EMISSIONS: CONSTRUCT RESPONSIBLY

NAPA says “A mix with 50 percent RAP can reduce cradle-to-gate (A1-A3) emissions by 29 percent compared to a mix without any RAP.

THE CARBON FOOTPRINT OF ASPHALT PAVEMENTS

A REFERENCE DOCUMENT FOR DECARBONIZATION

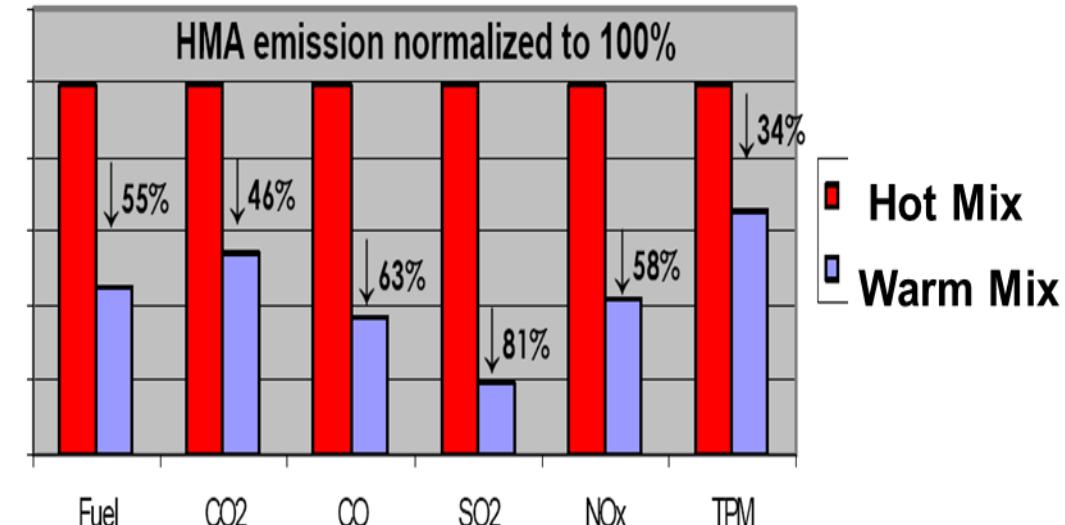
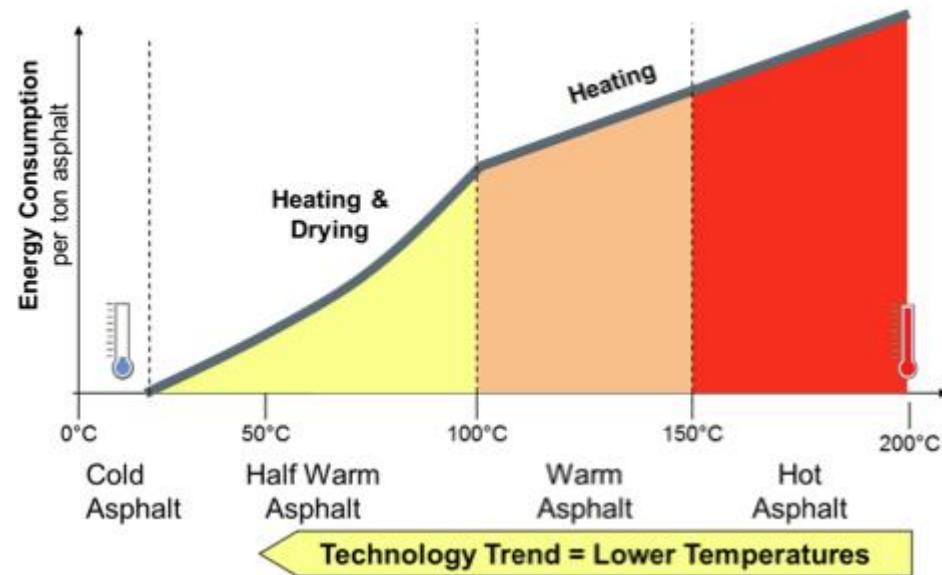
Joseph Shacat
Richard Willis, Ph.D.
Ben Ciavola, Ph.D.



WARM MIX ASPHALT

WMA

- “...a group of technologies which allow a reduction in the temperatures at which asphalt mixtures are produced and placed.”

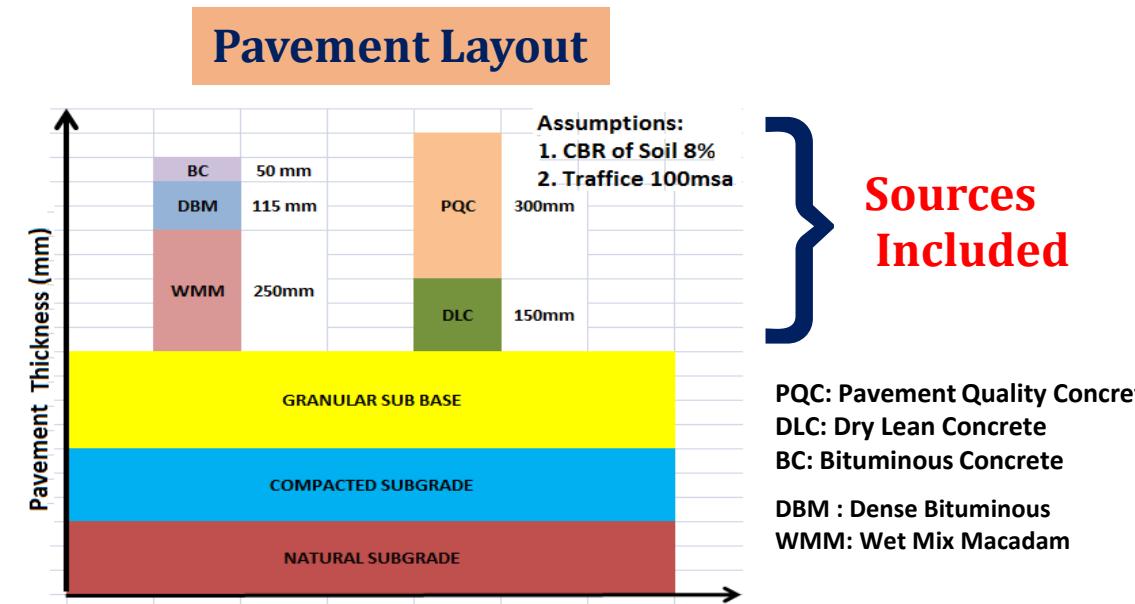


Warm Mix Asphalt (WMA)

- Fundamentally no different than HMA
- Production Temperature 20-30°C (35-55°F) lower

Comparison of GHG Emission

Input Material	CO ₂ Emitted (in Tonne CO ₂ eq)			
	Premix		Seal Coat	
	HMA	CMA	HMA	CMA
Bitumen/Emulsion	40.2	21.4	43.5	18.2
Crushed Aggregate	8.2		2.7	
During Construction	141.5	7.5	141.5	7.5
Total	189.9	37.1	187.7	28.4



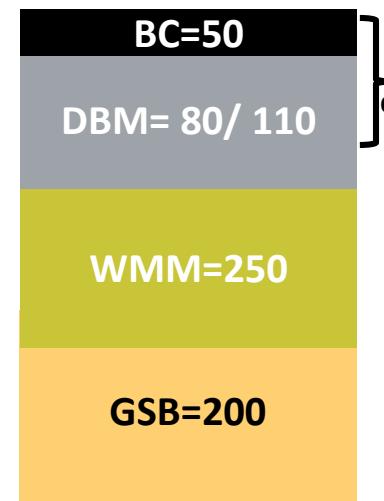
WMA		HMA	
Consolidated results:	tCO ₂ -eq	Consolidated results:	tCO ₂ -eq
Pre-construction	0	Pre-construction	0
On-site impacts	0	On-site impacts	0
Construction materials:	17390.0	Construction materials:	17980.0
Material transport:	9482.8	Material transport:	9482.8
Construction machines:	6.1	Construction machines:	6.1
Total CO₂ equivalent emissions:	26,878.7	Total CO₂ equivalent emissions:	27,469.1
	0		4

Methods	CO ₂ Emitted (in Tonne CO ₂ eq)	
	Rigid Pavement	Flexible Pavement
Embodied Energy	1246	95
During construction	6.6	84
Material Transport	46.7	40.7
Total	1299.3	219.7

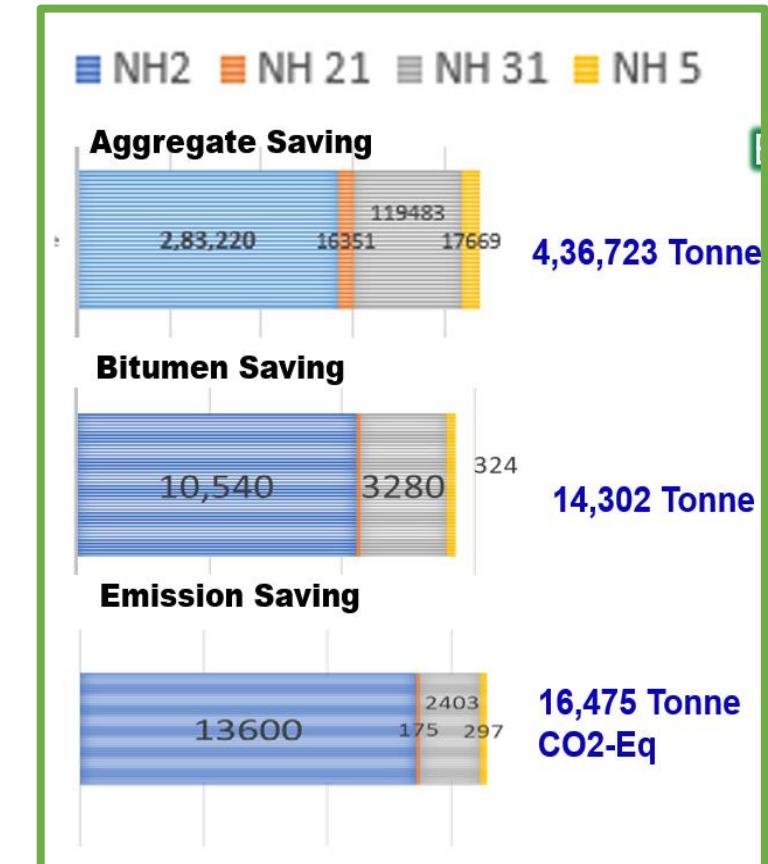
Cold-in-Place Recycling (CIPR)



Damaged Road

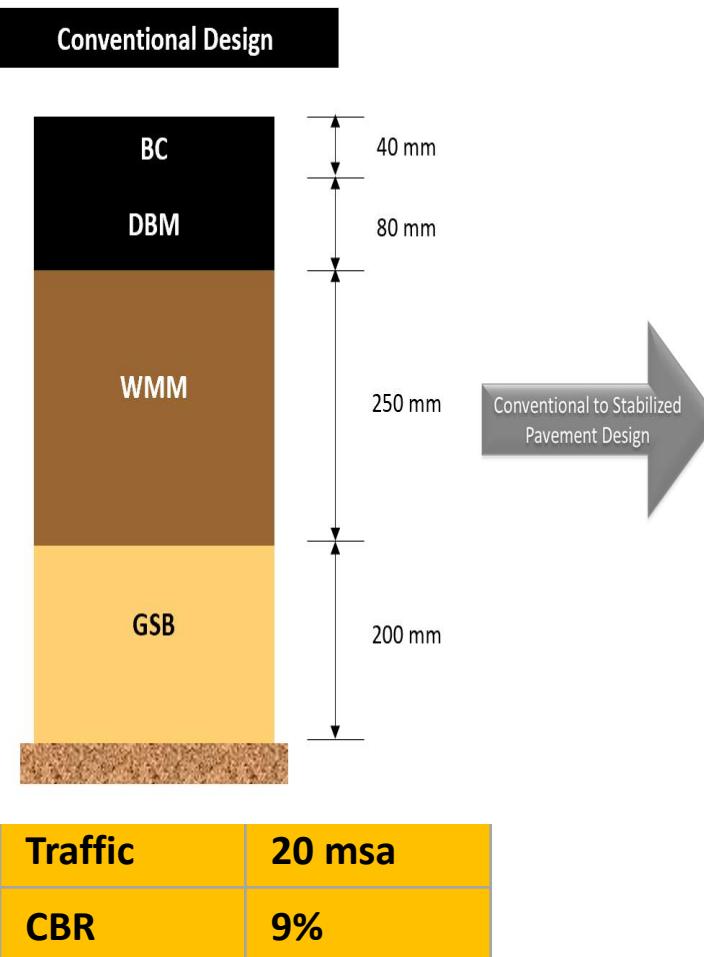


Field Implementation CIPR



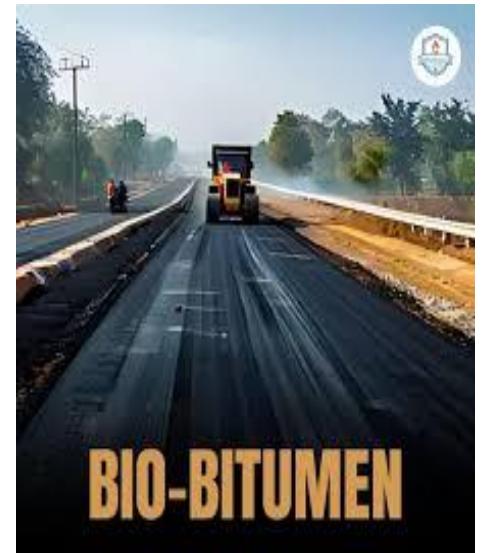
Benefits of CIPR

Optimize Design - Crust Reduction & Aggregate Savings



- Approximately **1,18,000 tons** of aggregate saved.
- Corresponding saving of **4000** truck trips and diesel requirement.

CARBON SMART ROADS



India's First Road Trial Using Technical Textiles Made from End-of-Life Plastic Launched

In a pioneering step towards sustainable infrastructure, CSIR-Central Road Research Institute (CRRI), in collaboration with Bharat Petroleum Corporation Limited (BPCL) and supported by the National Highways Authority of India (NHAI), launched India's first road trial using technical textiles made from end-of-life waste plastic.

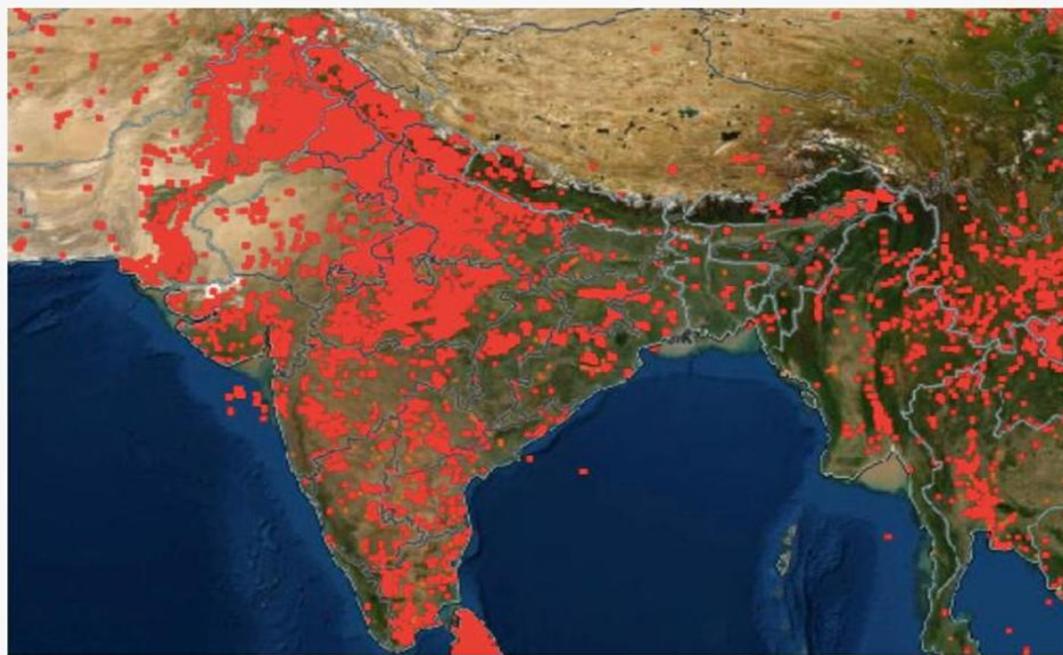


Development of *Bio-Bitumen* for Sustainable Roads



THE PROBLEM: Bitumen Shortage & Rising Pollution

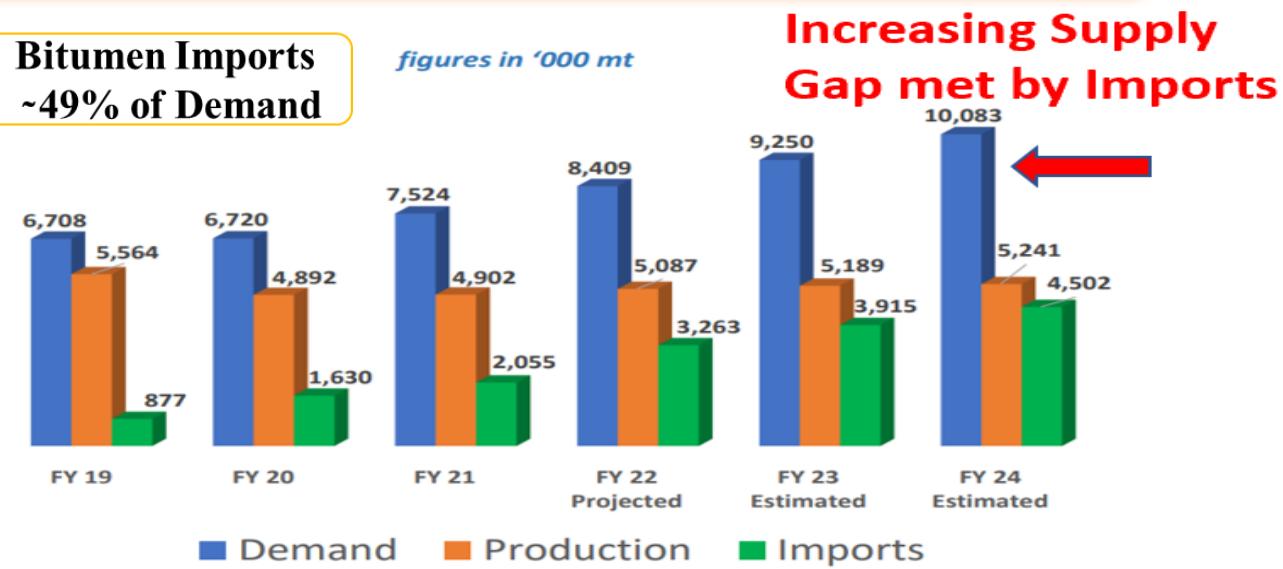
Crop fire points in India



STAGNANT DOMESTIC PRODUCTION

Bitumen Imports
~49% of Demand

figures in '000 mt



Increasing Supply
Gap met by Imports

ESTIMATED ANNUAL IMPORT COST: 25000 CRORES



THE SOLUTION : BIO-BITUMEN



Up to 30%
replacement of
conventional
Bitumen



CSIR-CRRI & IIP developed the process to produce bio-bitumen by doing pyrolysis of rice straw. The produced bio-bitumen was extensively tested by CRRI on all the performance parameters of a National Highway



World's First Field Trial of Bituminous Surface Layer with Bio-binder produced from Rice Straw/ Biomass Pyrolysis

Trial stretch on Jorabat to Shillong (Barapani) section of NH-6 (Old NH-40)

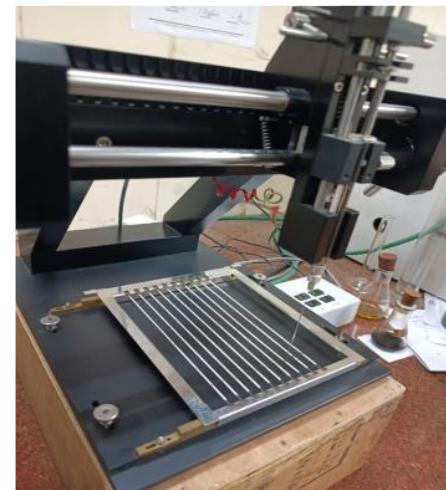
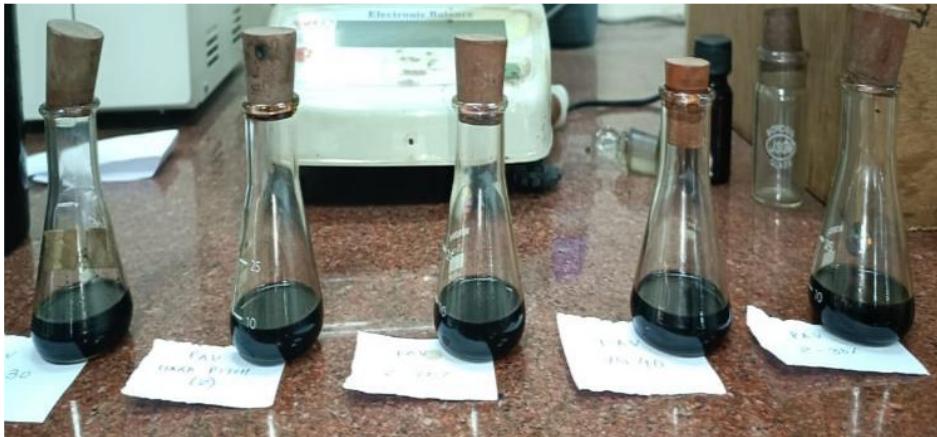
26th October 2024

**Technology Patent Filed
(Application no:202411063553,
Dt 23/08/2024)**

Chemical Properties: SARA Analysis

The composition of developed bio-bitumen is made similar as fossil-based bitumen

- SARA Analysis of pure bio-bitumen and petroleum Bitumen are performed.
- The following table indicates the Average weight percentage of Bitumen components present in bio-binder and bitumen samples.



Sample	Saturates,%	Aromatics, %	Resins,%	Asphaltenes, %
VG 40 (conventional petroleum based bitumen)	15.93	31.36	44.34	8.37
Sample	Saturates %	Aromatics %	Resins %	Asphaltenes %
Bio-Bitumen (30% replacement)	14.12	36.47	41.46	7.95

Bio-Bituminous Mix Evaluation

- Samples Prepared using Marshall Compactor
- BC-I: 5.2% Binder Content
- The coating and strength of bio-bitumen is found similar as conventional bitumen



Aggregates coated with bio-bitumen



Performance Evaluation of Bio-Bitumen Mix for strength, durability and moisture resistance parameters



Strength: ITS Test



Design Parameter: Resilient Modulus



Rutting: Dynamic Creep

Type of Mix	Indirect Tensile Strength (kPa)		Tensile Strength Ratio (%)	Resilient Modulus, MPa @ % 35 ° C	Permanent Axial Strain, % 50 ° C
	Dry	Wet			
Conventional VG 40	1105	1002	90.7	3350	1.80
Bio-Bitumen (30% replacement)	1050	962	91.6	3400	1.79

End-of-Life Plastic



Geocells

A geocell is a 3D honeycomb structure made from high-density polyethylene (HDPE) that creates a cellular confinement system to stabilize soil for various civil engineering applications like roads, retaining walls, and erosion control.

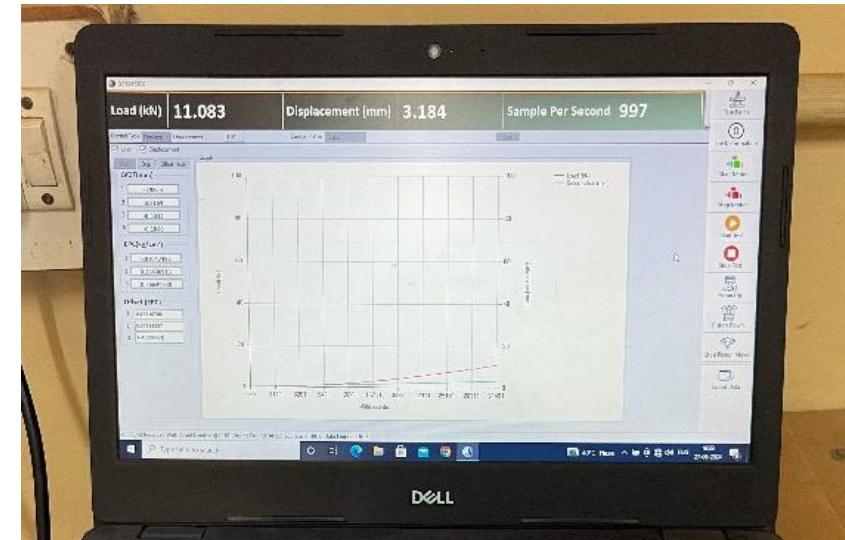


A First of Its Kind - Game Changer Product

PhoeniX



Laboratory Performance of PhoeniX



First Plant Trial – 21/01/2025

- Plant Trial at NH-709A Camp at Kithore Tata Projects Ltd.



India's First Road Section Constructed using Technical Textile made of End-of-Life Waste Plastic

Technical Textile – Geocell made from End of Life Waste Plastic



Laying of Phoenix Geo Cell



Inauguration of Construction of Road Section using Phoenix Geocell



Media Coverage

रेडीमेड सड़कों की जियोसेल तकनीक का होगा पेटेंट, प्लास्टिक निपटान होगा आसान

वी के ट्रॉला ● जाहरा

नई दिल्ली: अनुपयोगी एलाइटिक से रेडोमट सड़क बनाने के लिए तैयार की गई जियोसेल तकनीक का एंटेरेंट कार्यशाला जापान। 'भारत प्रोटोलिंगम' ने कैरोला साइक अनुपयोगी जियोसेल (सीआरआरआरजाइ) ड्राइवर तकनीक के परीक्षण के बाद एंटेरेंट के लिए, आवेदन किया है। इस जाय रहा है कि भारत नहीं, परे विश्व में भी अपने तक इस तरीके का प्रयोग नहीं हुआ है। इस तरीके में लगे भारत प्रोटोलिंगम और सीआरआरआरजाइ के विज्ञानी इसे बड़ी उपलब्धिमान रखे हैं। उनकी मानने तो एलाइटिक प्रौद्योगिक विकास की समर्पण है। सब कुछ थ्री-कॉन्क्रेट रुटा है। सब कुछ साधन में भारत हुस्ते देखो को भी इस मामले में मदद कर सकेना। इसी के साथ अनुपयोगी एलाइटिक से बनाए गए जियोसेल से सड़क अन्नने के काम का अन्न अन्नने का

- अनुपयोगी प्लास्टिक निरस्तरण के मापदंड में दुनिया भर की भारत कर सकता है फैसल
- विशेषज्ञ भारत से नई दुनिया भर में मान रहे हैं इस तरह के फैसला प्रयोग

ये हैं जिन्होंने लूट लियी

जियोसेल एक पत्र है जिससे ९-९
इय लंबाई, दौर्याई और ऊर्याई के
वाक्स बनाए जाते हैं, इसमें सङ्क
बनाने की कौलतार मिक्स समझी भर
जाती है ११०० मीटर सङ्क बनाने के
लिए करीब ३० टन तक अनुयोगी
लाइनिंग का नाला लगा दें, मजबूत है।

A wide-angle photograph of a large-scale construction project. In the foreground, a black geogrid is laid out in a grid pattern over a dark, granular base. The background shows a long line of construction equipment, including several bulldozers and trucks, parked along a dirt road. The surrounding area is a mix of green vegetation and dirt, indicating an active construction zone.

सराय काले खा के समीप नूप ने एक डीएनडी-फर्नीदावाद- कैप्समपी एक्सप्रेसवे पर अन्यायी लॉक्टिक से बदले जायेगेते ॥ जागरण

वायपरिशान के मुख्य महान् ग्रंथ डा. रीढ़ गुर्जर वाँ. वहाँ से जियोसेल की पत्रका पर प्रयोग से अनुपर्याप्ती एलास्टिक पौध उपलब्ध हो जाएगी। अनुपर्याप्ती एलास्टिक पौध जियोसेल की पुरानी और एक साथ जोड़ दिया करने से खुबी में कम कम 25 प्रतिशत की अवृत्त हो सकता है। इसके और वर्ड बैड और भूमि ही है। भारत देशवासियोंके मुख्य प्रबंधक डा. महाना कर्मान् वह कहते हैं कि लैंड्रिकल पर एक एलास्टिक जियोसेल से सारांश किया जा सकता है, कृष्ण बालाले उसे छोड़ देते हैं और लैंड्रिकल पर इसका ढेर लग जाता है। प्रयोग के दौरान वह बहुत नियमित

इस काम को शुरू किया जावे उन्होंने कहा कि इस तरह का प्रहला प्रयोग है, माना जा सकता है यह एक सामान उत्पाद से उत्पन्न से भी अधिक चल सके सीओउआरआइ को विस्तृत प्रयोगिता दी अंतिम बाल ने कि इन्हें यह एक प्रतिक्रिया उत्पादक के लिये जारी होने वाला प्रदूषण रुकै लोगों के रोजगार के मार्ग खुला रहते साइक्ल मजबूत होने और अनुप्रयोग प्रतिक्रिया की सम्भावना सामग्री का उत्पन्न होने वाली उन्होंने कहा कि भारत सरकार इस चारे में रिपोर्ट प्राप्ति है, जो कुछ टांक टांक रास तो पक रखने के अंदर इस पर काम शुरू कराएगा।

भारत पेट्रोलियम के अधिकारी ने पोर्टेट के आवेदन की पुष्टि की है। सीओउआरआइ के निदेशक ग्रोप मनोरंजन परिदा ने सीओउआरआइ और चीनी कंपनी नान लेन एंड एंड एंड एंड की

India's First Road Trial Using Technical Textiles Made from End-of-Life Plastic Launched

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THE ECONOMIC TIMES | Industry

Business News | Industry | Transportation | Roadways | India launches first field trial using waste plastic geocells to build roads in difficult terrains

India launches first field trial using waste plastic geocells to build roads in difficult terrains

ET Online | Last Updated: 7 Jul 13, 2025, 03:08:00 PM IST

Synopsi

The Central Road Research Institute and BPCL have innovated Geocells, crafted from end-of-life plastic, for road construction in challenging terrains. These three-dimensional modules, filled with soil or debris, are set for field trials with the Military Engineering Services.



In a new initiative to tackle **end-of-life plastic** waste, the **Central Road Research Institute** (CRRI) and **Bharat Petroleum Corporation Limited** (BPCL) have developed Geocells—three-dimensional block-shaped

A horizontal navigation bar at the bottom of the page. It includes links for 'FOLLOW US', 'SHARE', 'FONT SIZE', 'SAVE', 'PRINT', and 'CONTACT'. To the right of these links is the 'Star Health Insurance' logo, which features a five-pointed star above the text 'STAR' and 'Health Insurance'.

Waste to wonder: India's first road trial with plastic used for construction; Military and NHAI to test for load-bearing efficiency

Kushagra Dixit / TNN / Updated: Jul 13, 2025, 10:12 IST



WHAT IS REQUIRED FOR INDIA TO MARCH TOWARDS CIRCULAR ECONOMY IN ROAD CONSTRUCTION



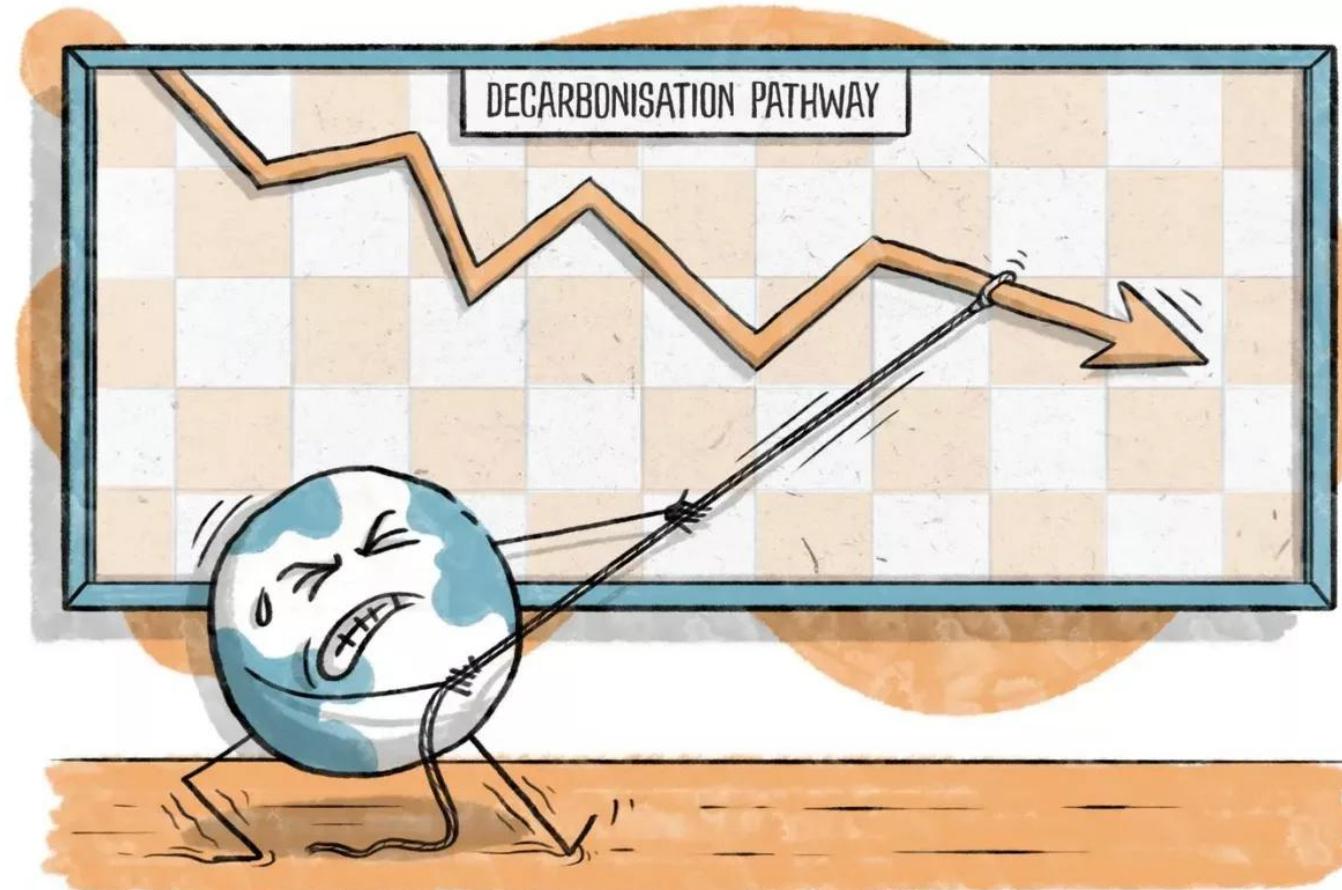
WHERE WE ARE?
WHAT WE HAVE?



WHAT WE DON'T HAVE?



Build Sustainably



Thank you

A handwritten signature in black ink, likely belonging to the author of the slide.