

Warsaw, 22 - 23 October 2025

II MIĘDZYNARODOWA KONFERENCJA

Nowoczesne nawierzchnie drogowe - recykling i dekarbonizacja

II INTERNATIONAL CONFERENCE

Modern road pavements - recycling and decarbonization

Feedback on recycling in France

Presented by Mathieu GALIANA - Université Gustave Eiffel



Plan

1. Historical background and **assessment** of recycling in France
2. **State of the art** in France : research projects, guidelines
3. **Outlook** for recycling
4. **Feedback** on AC with high rate of RAP





RECYCLING IN FRANCE

1 – Historical background and assessment

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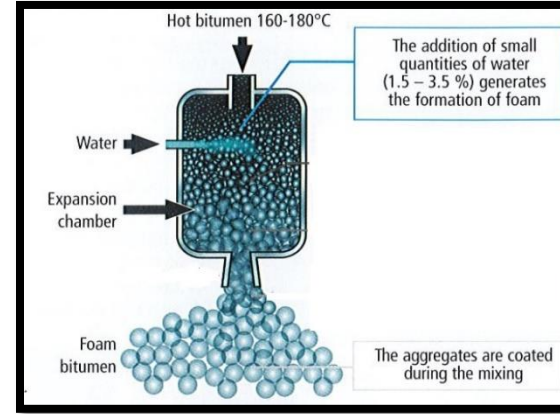


RECYCLING IN FRANCE

1 – Historical background

Vocabulary

- RAP : Reclaimed Asphalt Pavement
- AC : Asphalt Concrete
- HMA : Hot Mix Asphalt
- WMA : Warm Mix Asphalt



Two processes for **WMA** :

- additives ;
- foam bitumen



RAP

RECYCLING IN FRANCE

1 – Historical background



PN MURE Programme de recherche MURE
Multi-Recyclage des Enrobés tiède
ANR IMPROVMURE

1980

First works with
HMA containing
RAP

2000

Development &
combination of
recycling with
WMA

2015

French law for
ecological
transition for
green growth

2021

-Results of PN
MURE
-French guide on
recycling

1980-2005 - National RAP
content $\approx$ 10%

Since 2010 -National
RAP content $\nearrow$

In 2020, for AC, minimum
values of RAP content
should be :

- 30% for base layers
- 20% for surface layers

Historical sources : Yves BROSSEAUD, Ifsttar





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1 – Environmental assessment in 2024

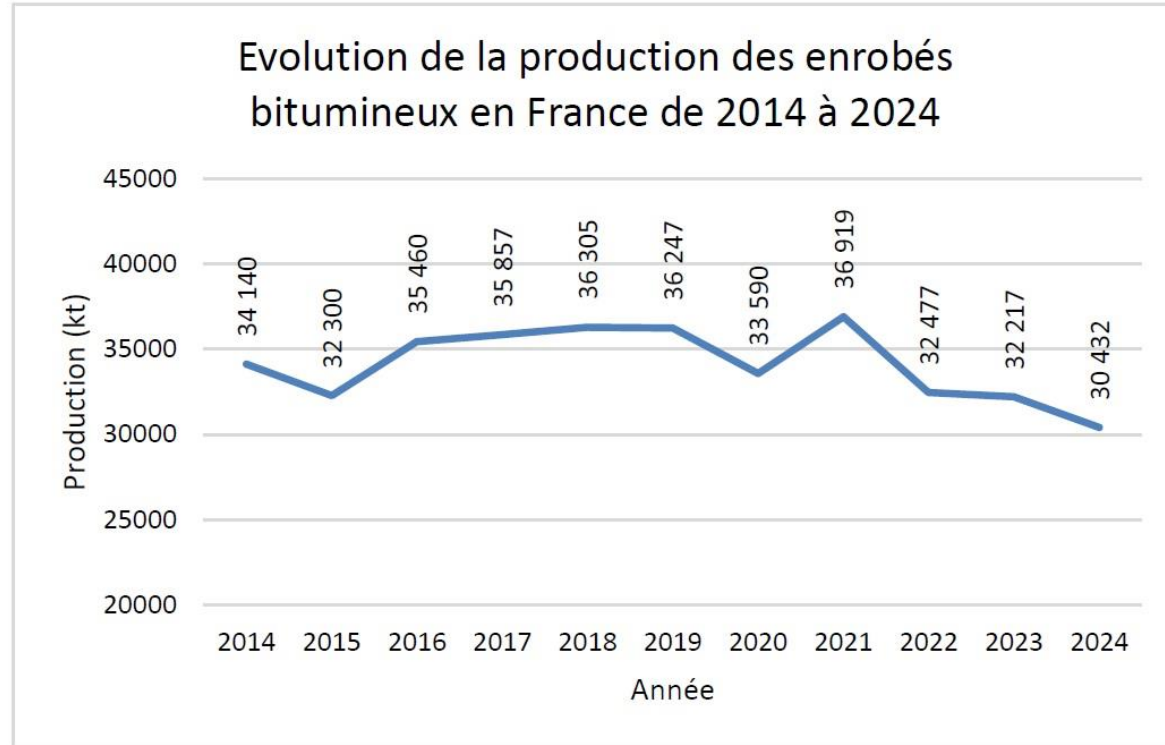
BILAN ENVIRONNEMENTAL RAPPORT ANNUEL - DONNÉES 2024



Juin 2025



30 million tonnes of Asphalt concrete produced in France in 2024



Source : Routes de France



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1 – Environmental assessment in 2024

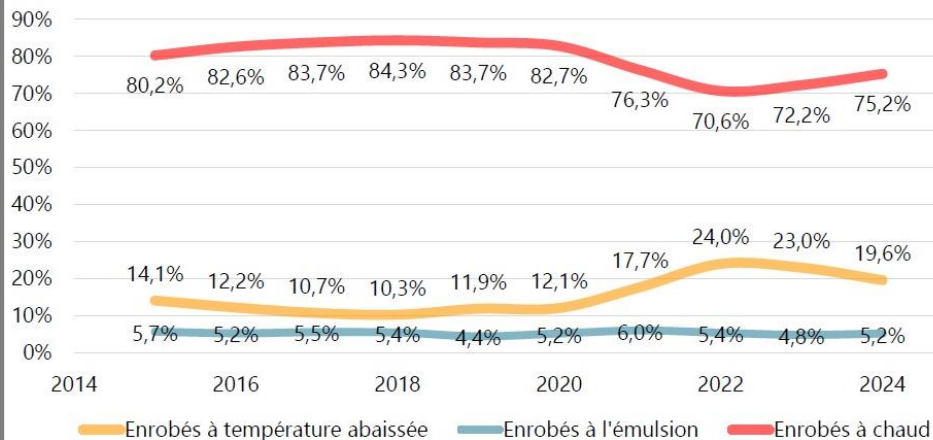
Annual production of mix asphalt (depending on the process)

WMA

Cold Mix Asphalt

HMA

Répartition de la production annuelle d'enrobés bitumineux
selon les procédés de fabrication depuis 2015



RAP content in the mixtures

In 2024, RAP content = 25%

Objective : 30% RAP in 2030



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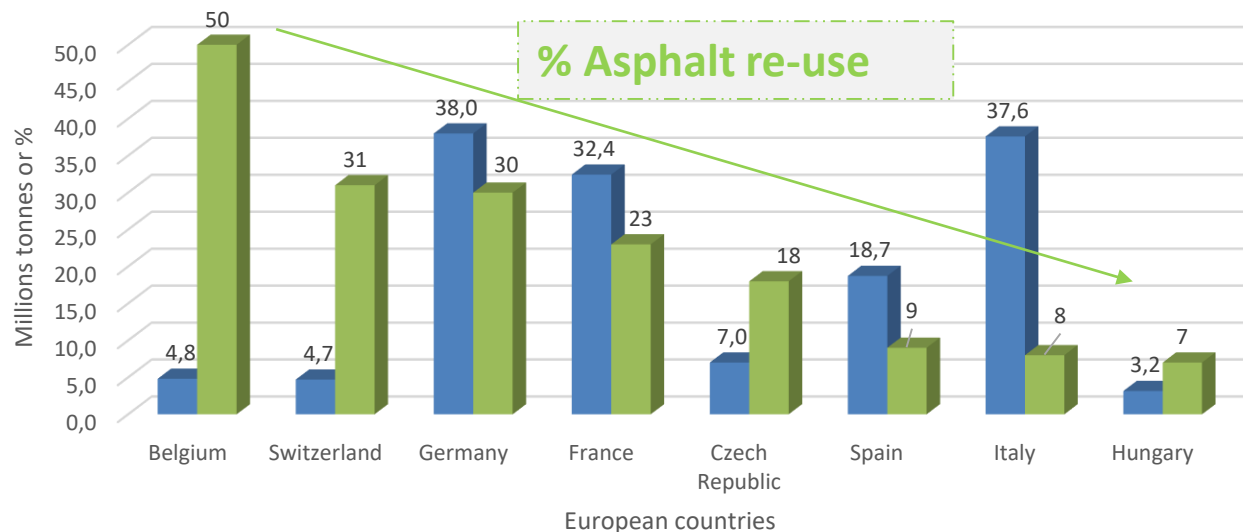
RECYCLING IN FRANCE

1 – Environmental assessment in 2024

Comparison with other European countries

In Poland, 19 millions tonnes of HMA and WMA produced in 2023
% Asphalt re-use < 10%

Circular economy (EAPA - data 2023)



Sources : Asphalt in figures 2023 (EAPA)

Data checked for Belgium, Switzerland, Germany, Italy, Spain, Poland

Acknowledgments : C. Raab (EMPA) ; K. Mantalovas and D. Lo Presti (University of Palermo) ; A.Destree (BRRC) ; F. Moreno (University of Granada) ; W. Bankowski and M. Gajewski (IBDIM)

■ Total production
(in millions tonnes)

■ % Asphalt re-use

$\% = \frac{\text{amount of RAP used in AC}}{\text{total AC production}}$

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2 – State of the art in France

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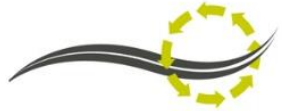


RECYCLING IN FRANCE

2 – State of the art in France

Conclusions of national project MURE

Guidelines on mix asphalt containing RAP



PN MURE Programme de recherche MURE
MUlti-Recyclage des Enrobés tiède
ANR IMPROVMURE

→ Standard values are given by the European standards (EN 13108)





RECYCLING IN FRANCE

2 – State of the art in France

Conclusions of MURE national project (Multi-recycling)

- Same properties for AC with 0% and 40% of RAP;
- AC with 70% of RAP : values close to minimum standard values ; performances decrease with RAP rate
- Multi-recycling (until 3 times) has a little effect on properties.
- Feedback is necessary to get information on durability
- <https://pnmure.fr/> (in French)
- MURE National project follow up (in english) → <https://dvdc.fr/restitution-np-2023-content-en/>



RECYCLING IN FRANCE

2 – State of the art in France

Guide « recyclage » published in 2021



Scope :

- Hot Mix Asphalt (HMA)
- RAP content between 10 et 40%

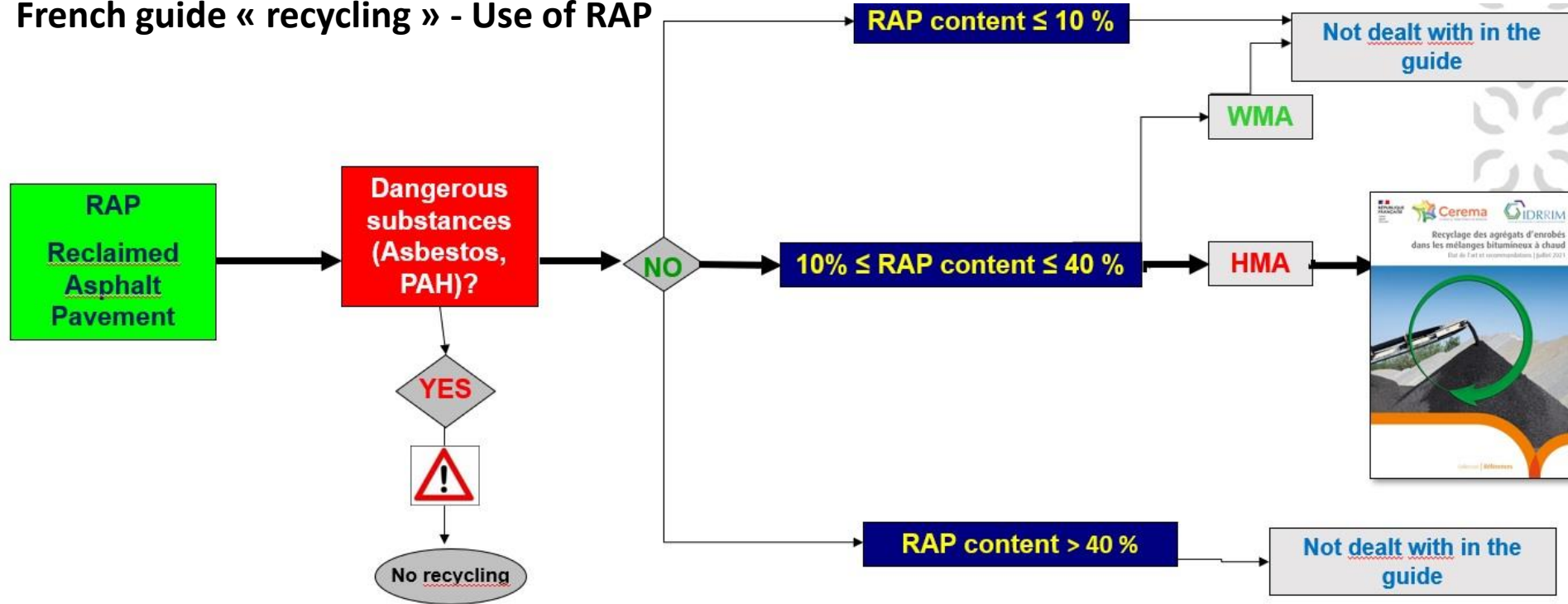
-French working group to follow the application of this guide



RECYCLING IN FRANCE

2 – State of the art in France

French guide « recycling » - Use of RAP



PAH : Polycyclic Aromatics Hydrocarbons

Conditions for RAP allowed in HMA :

PAH (16) ≤ 50 mg/kg and Hydrocarbons C10-C21 ≤ 300 mg/kg

RECYCLING IN FRANCE

2 – State of the art in France

Guide « recyclage » published in 2021



Guide divided into 6 Chapters :

- RAP production
- **RAP identification**
- Type testing validity
- **AC Manufacturing**
- AC implementation
- **AC with RAP content > 30%**



RECYCLING IN FRANCE

2 – State of the art in France

Class vs RAP content : specifications on RAP for surface layers

Source : guide 'recyclage'
IDRRIM Cerema 2021

- Characteristics of RAP :
- TL = Binder content [TL_0 ; TL_1 ; TL_2 ; TL_{NS}]
- B = Penetrability and/or softening point of bitumen [B_0 ; B_1 ; B_2 ; B_{NS}]
- G = Granulometry [G_0 ; G_1 ; G_2 ; G_{NS}]
- R = Intrinsic characteristics of aggregates [R_0 ; R_1 ; R_2 ; R_{NS}]

Nature de la couche	Taux de recyclage (en %)	Classes			
		TL	B	G	R
Roulement	]10 ; 20]	TL_2	B_1	G_2	$R_2^{(1)}$
	]20 ; 30]	TL_1	B_1	G_1	R_1
	]30 ; 40] ⁽³⁾	TL_1	B_0	G_1	R_1

Rate of RAP

Characteristics of RAP (TL, B, G, R)

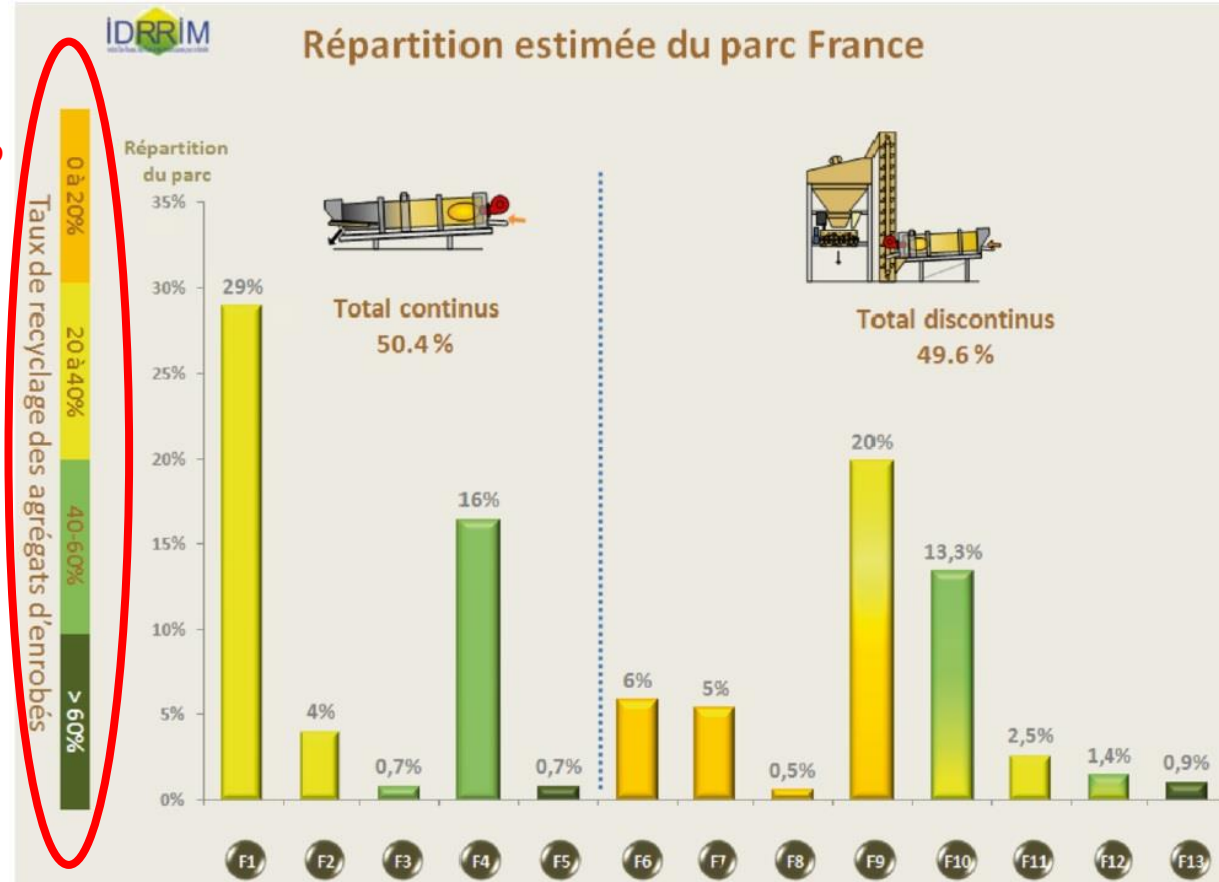
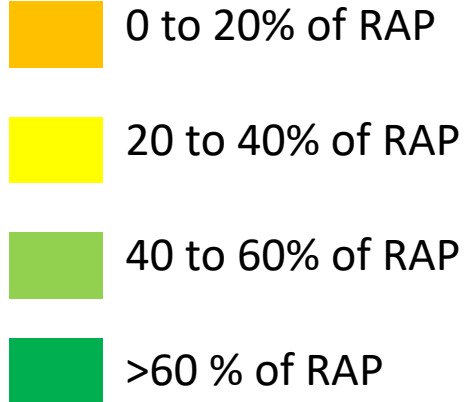


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2 – State of the art in France

Manufacturing

Rate of RAP





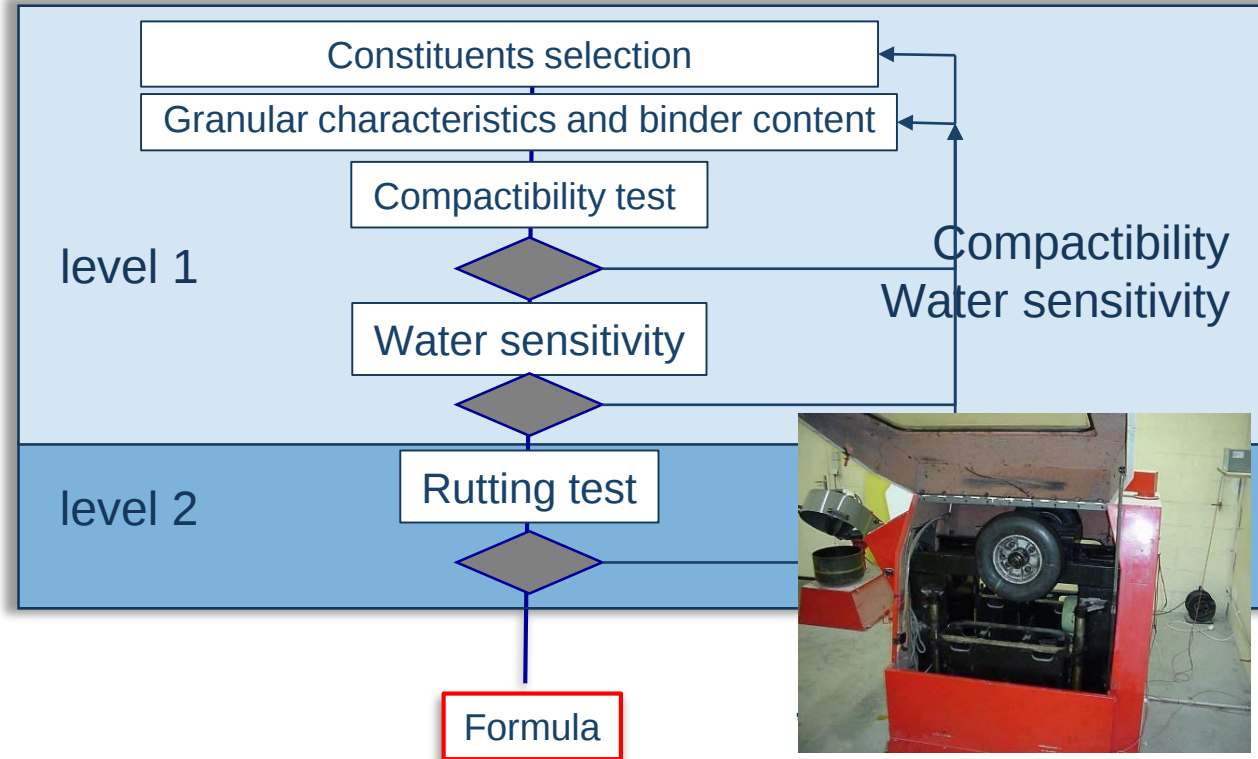
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2 – State of the art in France

Recommandations for surface layers with higher rate of RAP (>30%)

Type testing

- Perform type testing with the rate of RAP
- Increase frequency of tests on RAP
- Sourcing of local factories is necessary





RECYCLING IN FRANCE

3 – Outlook for recycling in France

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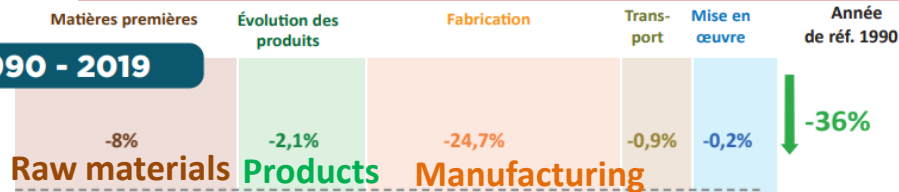
3 – Outlook for recycling in France

Decarbonisation roadmap for the road industry

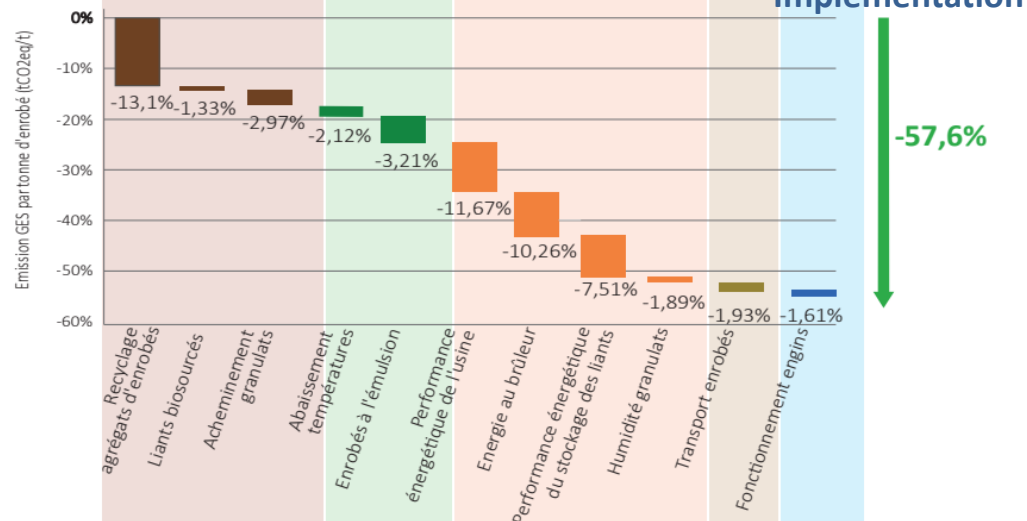
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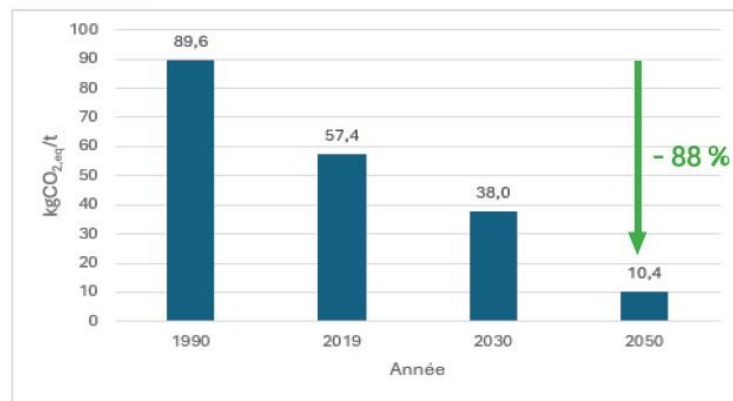
1990 - 2019



Scénario 2030



Scénario 2050





RECYCLING IN FRANCE

3 – Outlook for recycling in France

Solutions to reduce carbon footprint of AC (CO₂eq/t) :

- Use burner with natural gas and no fuel oil
- Use binder parks with more efficient temperature maintenance system (electric)
- Protect aggregates storage (sand and RAP)
- Improve factories energetic performance
- Use process such as WMA or cold mixture.
- Increase rate of RAP in bituminous mixtures



Electric park



Storage of RAP



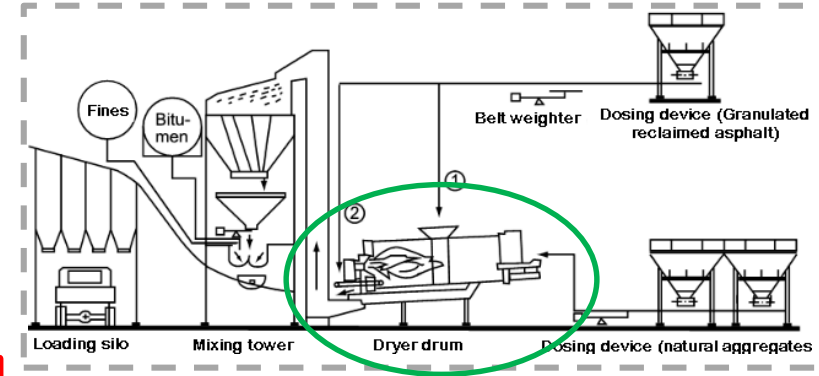
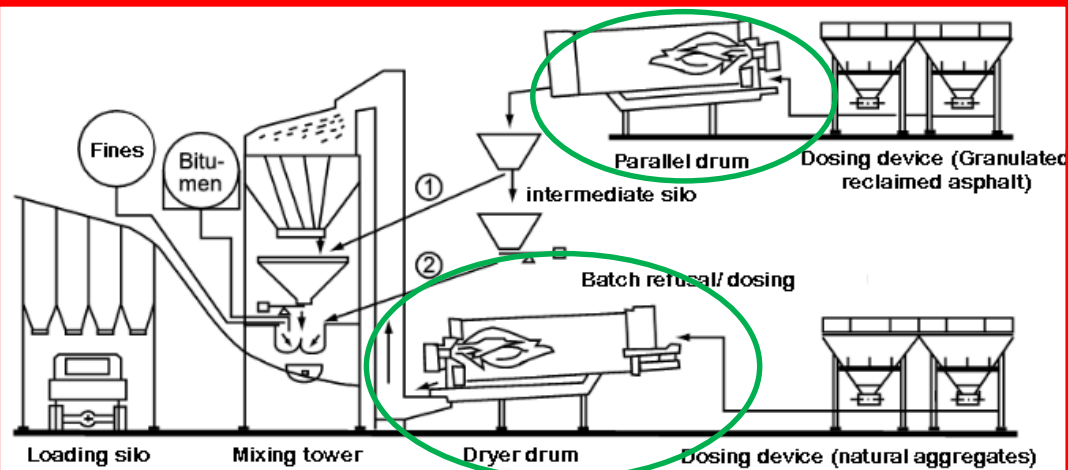
RECYCLING IN FRANCE

3 – Outlook for recycling in France

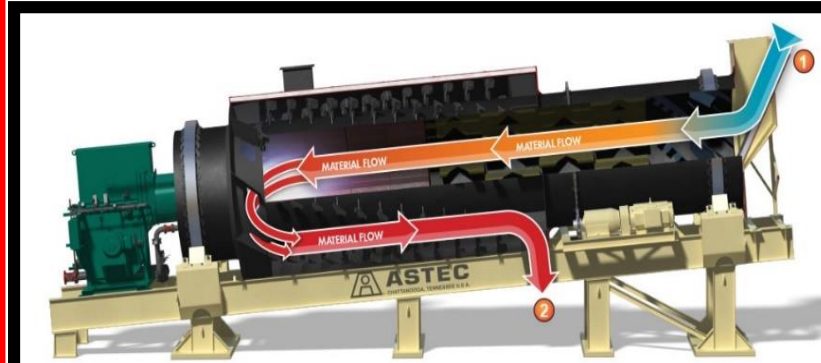
Recommended equipments to increase RAP rate

With ring for recycling (RAP rate $\leq 40\%$)

Double barrels (RAP rate $>40\%$)



Double envelope (RAP rate $>40\%$)





RECYCLING IN FRANCE

4 – Feedback on AC with high rate of RAP

4- Feedback on AC with high rate of RAP



RECYCLING IN FRANCE

4 – Feedback on AC with 40 % RAP

- **Feedback for base layers with 40% RAP**





RECYCLING IN FRANCE

4 – Feedback on AC with 40 % RAP

- AC containing 40 % RAP used in base layer

Surface layers

AC 14 base layer
40% RAP

- Collaborative research between **Cerema** and **Gustave Eiffel University** in partnership with road managers (**DREAL Pays de la Loire, DIRO, DIRIF**)
- National roadways (RN184, RN171)
- Works were realized by road companies COLAS (RN171) and EIFFAGE (RN184) in 2019





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4 – Feedback on AC with 40 % RAP

Mechanical performances :

- Properties comparable to AC without RAP ;
- Low void content and high stiffness modulus

	AC 14 (40% RAP)	Reference NF EN 13 108-1
Void Content	1 to 3 %	7 to 10 % (class3) 5 to 8 % (class4)
Binder content	≈ 4,8 %	
Stiffness modulus E(15°C, 10Hz) NF EN 12 697-26	>13 000 MPa	>9 000 MPa (class3) >11 000 MPa (class4)
Fatigue resistance ϵ_6 (10°C, 25 Hz) NF EN 12 697-24	111 μdef	>90 μdef (class3) >100 μdef (class4)
Thermal stress restrained specimen tests (TSRST) Cracking temperature and stress NF EN 12 697 – 46	T ≈ -17°C $\sigma \approx 3,5 \text{ MPa}$	No specification



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4 – Feedback on AC with high rate of RAP

- **Case of EME**



RECYCLING IN FRANCE

4 – Feedback on EME (High Modulus Mixtures)

- EME 2 are AC used in base layers because of their properties in stiffness modulus ($\geq 14\,000$ MPa) and fatigue resistance (≥ 130 μ def)
- Recycling with EME is possible as other ACs in base layers but with some warnings :
 - EME is characterised with hard bitumen. So be careful with the rate of RAP and the hardness of bitumen of the mixtures
 - Due to its high stiffness, EME should be applied on soil structure with high bearing capacity (PF2+ , ≥ 80 MPa)

AC14 (EME 0/14)**EME 0/14
Class 2
25% RAP**



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CONCLUSIONS



RECYCLING IN FRANCE CONCLUSIONS

- Using RAP in bituminous mixture is common in France ;
- In France, content of RAP in AC is around 25 %.
 - Objective 2030 : 30 %
- Guidelines are written for RAP content until 40 % ;
 - Distinction has to be made between surface layers and base layers
 - Feedback is necessary to get information on durability
- First feedback is positive.
- Examples presented here shown that for AC containing 40 % RAP :
 - Void content is low and stiffness modulus is high ;
 - Properties are conformed to expected values



**Don't throw away your old
roads
Reuse and recycle them !**



RECYCLING IN FRANCE

Thank you for you attention !

Special thanks to Ferhat Hammoum (UGE) ; Cédric Petiteau (UGE) and Benjamin Templier (UGE) for their reviewing

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Special thanks to Cerema, public works companies (Colas, Eiffage) and road managers involved in studies presented on national roads (DiRIF, DIRO, DREAL Pays de la Loire).

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