

**DIRECT
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WP4: Demolition of asphalt pavements and the recycling of road materials in asphalt

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WP 4: Objectives

- European knowledge transfer on experience on **end-of-life strategies for asphalt pavements**:
 - Dismantling techniques for asphalt pavements
 - Use of recycled road material in new asphalt pavements
- Synthesized literature and site data review:
 - Current state of the art / Specification
 - Experiences and Research results
- Best practice guide
 - Consideration of socio-economic conditions
 - Available technology



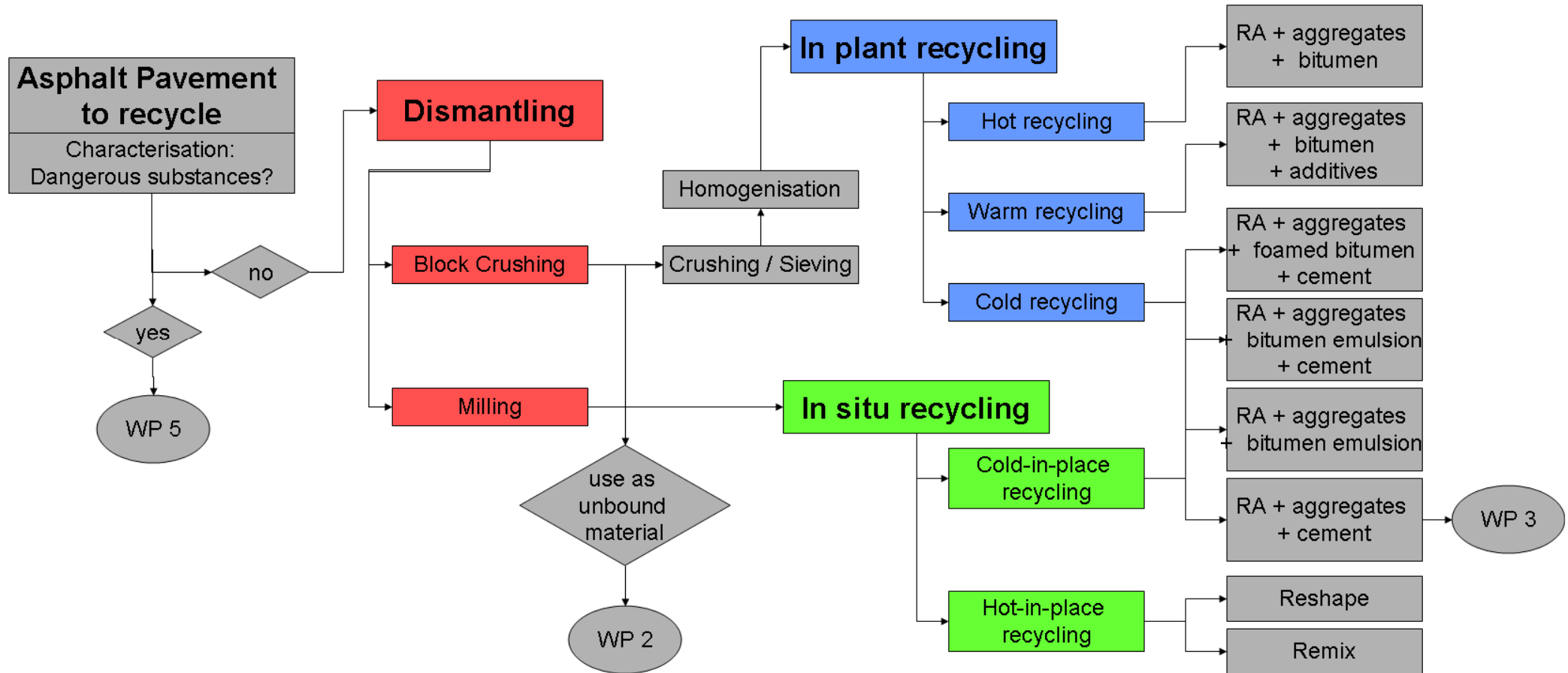
First result: Deliverable D5

Synthesis of national and international documents on existing knowledge regarding the recycling of reclaimed road materials in asphalt

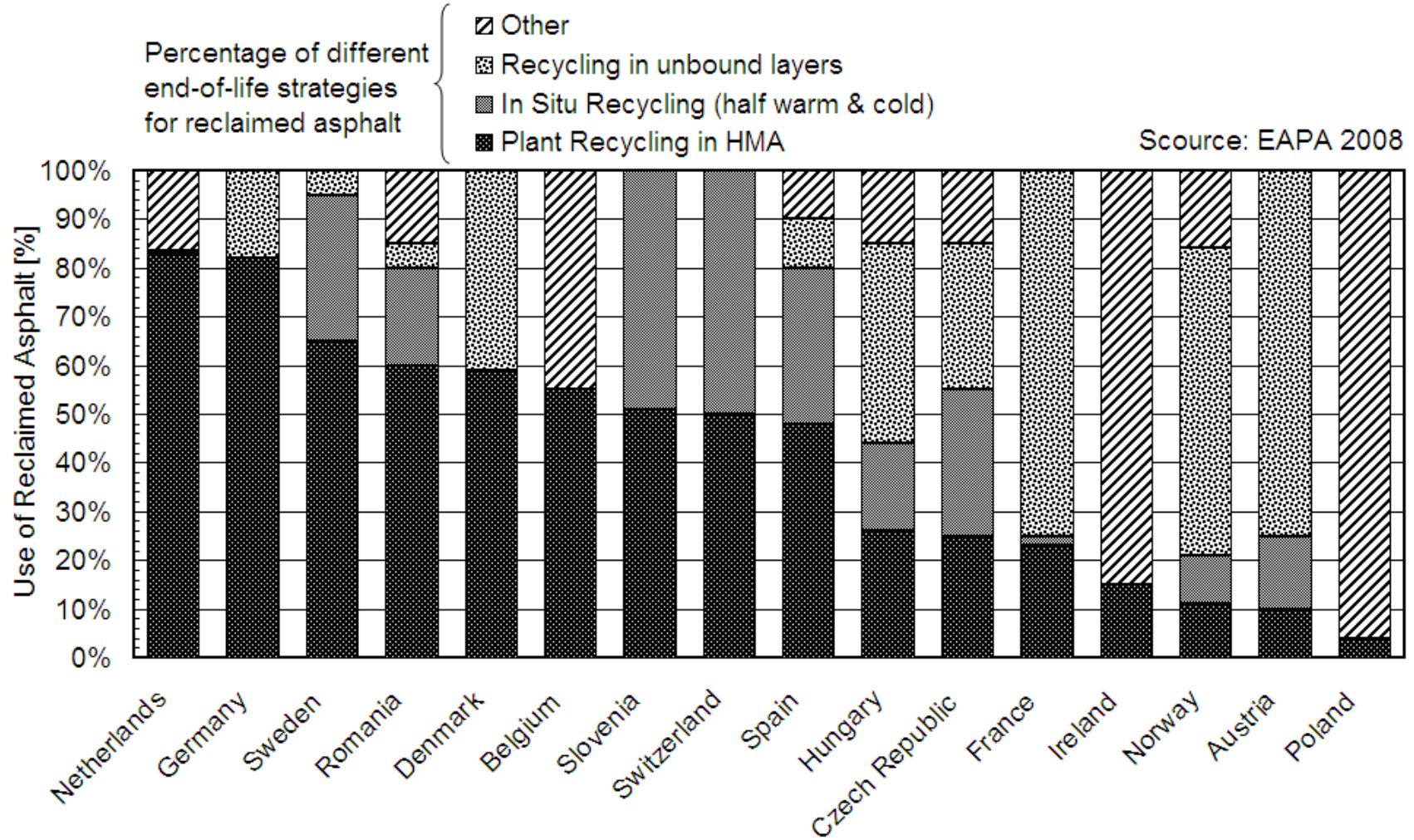
Table 1 List of Authors		
Country	Beneficiary	Authors
Belgium	BRRC	Luc e Bock
Denmark	DRI	Erik Olesen
France	LCPC	Yves Brosseaud
Germany	TUBS	Konrad Mollenhauer
Hungary	KTI	Laszlo Gaspar
Ireland	UCD	Ciaran McNally, Amanda Gibney
Poland	IBDiM	Krzysztof Mirski
Portugal	LNEC	Fatima Batista, Maria L Antunes
Serbia	IP	Milorad Smiljanic
Slovenia	ZAG	Aleksander Ipavec, Primoz Pavsic
Spain	CEDEX	Baltasar Rubio, Francisco Sinis
Sweden	VTI, SGI	Robert Karlsson, Ola Wik



WP 4: Recycling Techniques



Recycling of asphalt in Europe



Demolition of asphalt roads

Table 2 Recommendations for the demolition of asphalt pavements

Country	Recommended or usually applied demolition technique				Recommended after treatment and storage condition		
	Milling layer by layer	Milling	Crushing to blocks	Prior Removal of road marking	Crushing	Homogenisation	Storing separately by characteristics / source
Belgium		X			X	X	X
Denmark							
France							
Germany	X			X	X	X	X
Hungary							X
Ireland	X*	X	X		X	X	
Poland	X**						
Portugal							
Serbia	X		X				
Slovenia	X			X	X	X	X
Spain	X*				X		X
Sweden	X			X	X	X	X

* for In-Situ recycling
 ** for road maintenance



Recycling of road materials in asphalt



- Recycling of unbound material:
 - Possible in most, uncommon in all countries
- Recycling of hydr. bound material:
 - Possible in most, uncommon in all countries
- Recycling of reclaimed asphalt (RA):
 - Use of RA in plant mixed HMA technically equally to "normal" HMA
 - Cold-mixes (plant & in-place) suitable for base layers or low trafficked roads



RA: Technical requirements

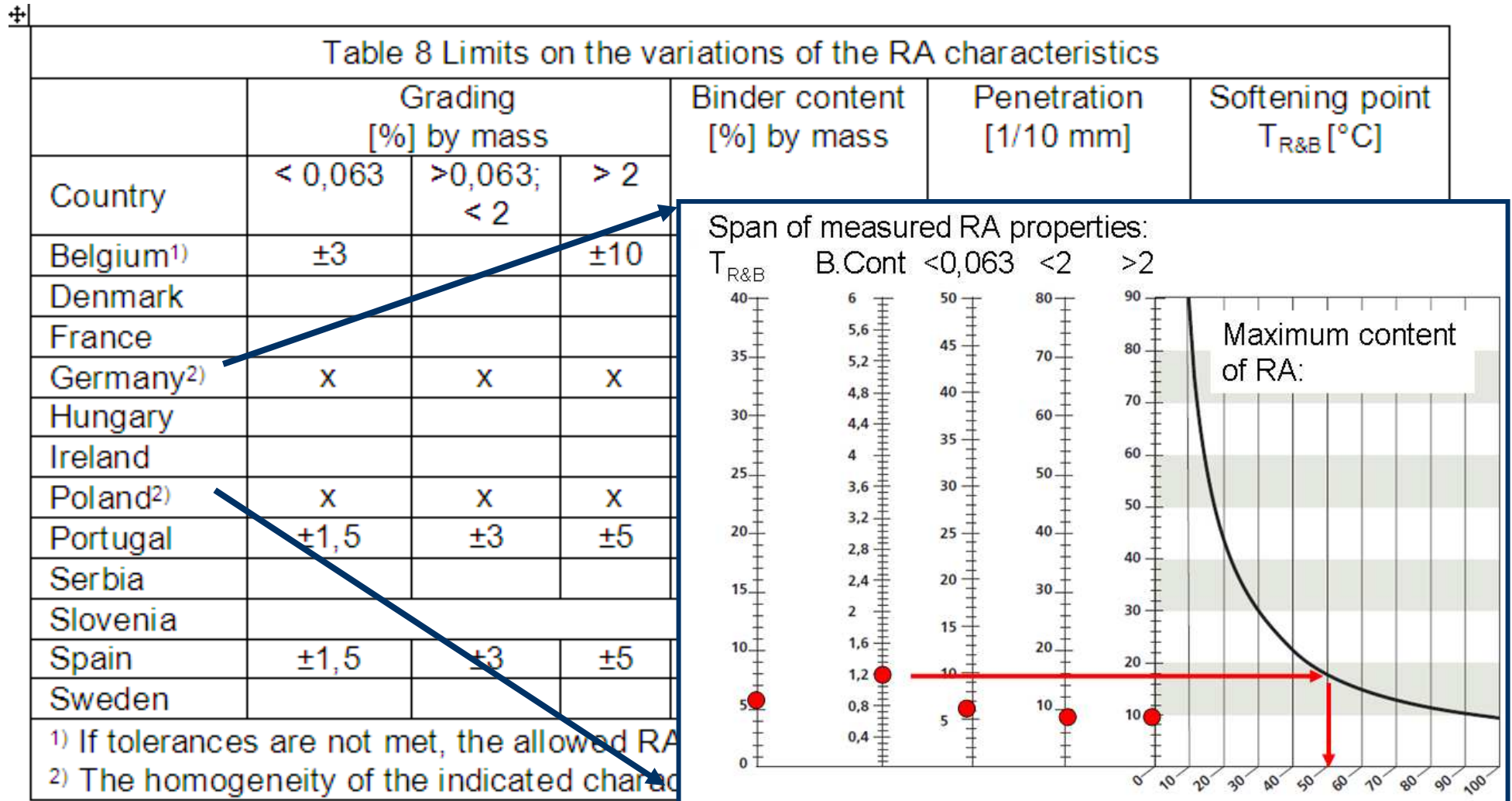


Property		Country											
		Belgium	Denmark	France	Germany	Hungary	Ireland	Poland	Portugal	Serbia	Slovenia	Spain	Sweden
Reclaimed asphalt	Maximum grain size U [mm]	x			x		28	40	32		32		Performance specification on the resulting mix ³
	Binder content [%]	x			x		x		x		x		
	Max. Density ρ_m				x						x		
	Content of foreign matter				x			x	x				
Aggregates	Type of aggregate	x			x		same as for virgin aggregates						
	Grading	x			x				x		x		
	Shape index	x			x						x		
	Flakiness index				x								
	Crushed surfaces				x						x		
	Los Angeles Coefficient				x								
	Polished stone value				x ²								
	Water absorption				x								
	resistance to freezing and thawing				x								
	resistance to freezing and thawing (NaCl)				x ²								
Binder	Type of binder				x				x		x		
	T _{R&B} [°C]	x			70			70	70		70		
	Pen [1/10 mm]	10 ¹			15		15 ⁴	15	15				
	Viscosity @ 135°C	x											

x: Specification needed for the characterisation of RA
¹ or 50 % of initial value
² for the recycling in surface courses
³ no specification on the constituent materials needed
⁴ for RA content of > 10 %



Homogeneity of RA



Maximum RA content & mix design



Table 10 Maximum allowed percentage of RA in HMA and mix design requirements

Country	Maximum allowed percentage of RA in HMA for			Use of equation 1 and/or 2	$D_{RA} \leq D$	Other mix design requirement
	Surface course	Binder course	Base course			
Belgium	25 %		50 %	x	x	x ¹⁾
Denmark	20 %	20 %	100 %			
France	$T_{R\&B,m} = \frac{b_0}{100} \times T_{R\&B,o} + \frac{b_n}{100} \times T_{R\&B,n}$ $\log \text{pen}_m = \frac{b_0}{100} \times \log \text{pen}_o + \frac{b_n}{100} \times \log \text{pen}_n$ $\log \log G^*_m = \frac{b_0}{100} \times \log \log G^*_o + \frac{b_n}{100} \times \log \log G^*_n$			x		
Germany				x	x	x ^{2),3)}
Hungary				x	x	
Ireland						
Poland				x	x	x ^{2),3)}
Portugal						
Serbia						
Slovenia	not defined			-	x	x ³⁾
Spain	-	10 % – 50 %				x ¹⁾
Sweden	20 %	30 %		Performance specifications		

1) in Flanders, the proportion of bitumen originating from RA in the binder of RHM for base courses of roads is limited
 2) The virgin binder used in asphalt mixes with RA may be one grade to the lower viscosity than the usual suitable binder
 3) virgin binder should not be softer than 70/100



Mix design techniques

Strategies in mix design:

- Homogeneity of RA:
 - According to classes: Belgium, Portugal, Spain
 - Functionally: Germany, Poland
- Design of mixing plant:
 - Belgium, France, Germany, Poland, Spain
- Same performance requirement:
 - Sweden, France, (Germany)
- Lower / no requirements on RA for small RA contents
 - Ireland, France (10 %)



In-situ recycling



Summary of the use of in-situ recycling in Direct-mat countries	
Portugal (PT)	Cold recycling used since 1993. Hot recycling on some demonstration projects in the late 1980's.
Sweden (SE)	Cold, warm and hot techniques are used on a regular basis. A treatment selection guide and a handbook support recycling actions.
Denmark (DK)	Uses hot remixing.
Spain (ES)	Has gained considerable experience in cold recycling.
Belgium (BE)	Hot techniques were used for ten years beginning in 1977, but thereafter outcompeted by in-plant techniques.
Germany (DE)	Experience from hot remixing and from manufacturing of remixing equipment. Reported favourable calculations of reduced CO2 emissions using cold recycling.
France (FR)	Cold recycling with foamed bitumen and bitumen emulsions are used. Hot techniques have been abandoned because of their great need for heat and poor workers conditions.



Conclusions



Conclusions from literature review:

- Reclaimed asphalt is recycled in most countries in new road materials up to a rate of 100 %
- Considerable differences in applied strategies due to socio-economic differences
- Innovative technology and experiences not available everywhere
- General specifications often allow higher recycling rates than actually applied in practice
- Synthesis of site data needed for data validation

