CEDR Transnational Road Research Programme
Call 2012: Recycling: Road construction in a post-fossil fuel society

funded by Denmark, Finland, Germany,
Ireland, Netherlands and Norway

CEDR
Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

AllBack2Pave

Towards a sustainable 100% recycling of reclaimed asphalt in road pavements

- Sustainability Assessment -

Dr. Davide Lo Presti

International Workshop on Recycling: Road Construction in a post-fossil fuel Society

TECHNISCHE UNIVERSITÄT DRESDEN
The University of Nottingham
UNIVERSITÀ DEGLI STUDI DI PALERMO

Defining Sustainability

"Time is nature's way of keeping everything from happening at once." — Woody Allen

"I think God's going to come down and pull civilization over for speeding."— Steven Wright

"Western civilization is a loaded gun pointed at the head of this planet." — Terence McKenna

"At its heart is the simple idea of ensuring a better quality of life for everyone, now and for generations to come" — "A better quality of life - strategy for sustainable development for the United Kingdom 1999"

Defining Sustainability

AllBack2Pave

"Every profession bears the responsibility to understand the circumstances that enable its existence." — Robert Gutman, writer

Construction carbon 15% reduction, target by 2012
Strategic Forum for Construction & Carbon Trust, Scoping paper, March 2010

Phasing out landfilling and Maximization of recycling (70-80%) 2025 – 2030 for plastic, glass, ferrous metals and aluminium - EU legislation 2014

Developing best practices and maximize recycling by minimizing the impact

Vision

Sustainable development of transport infrastructures

Technologies development

<u>Secondary materials</u>

RA

Testing

Modelling

On-site Experience

Design

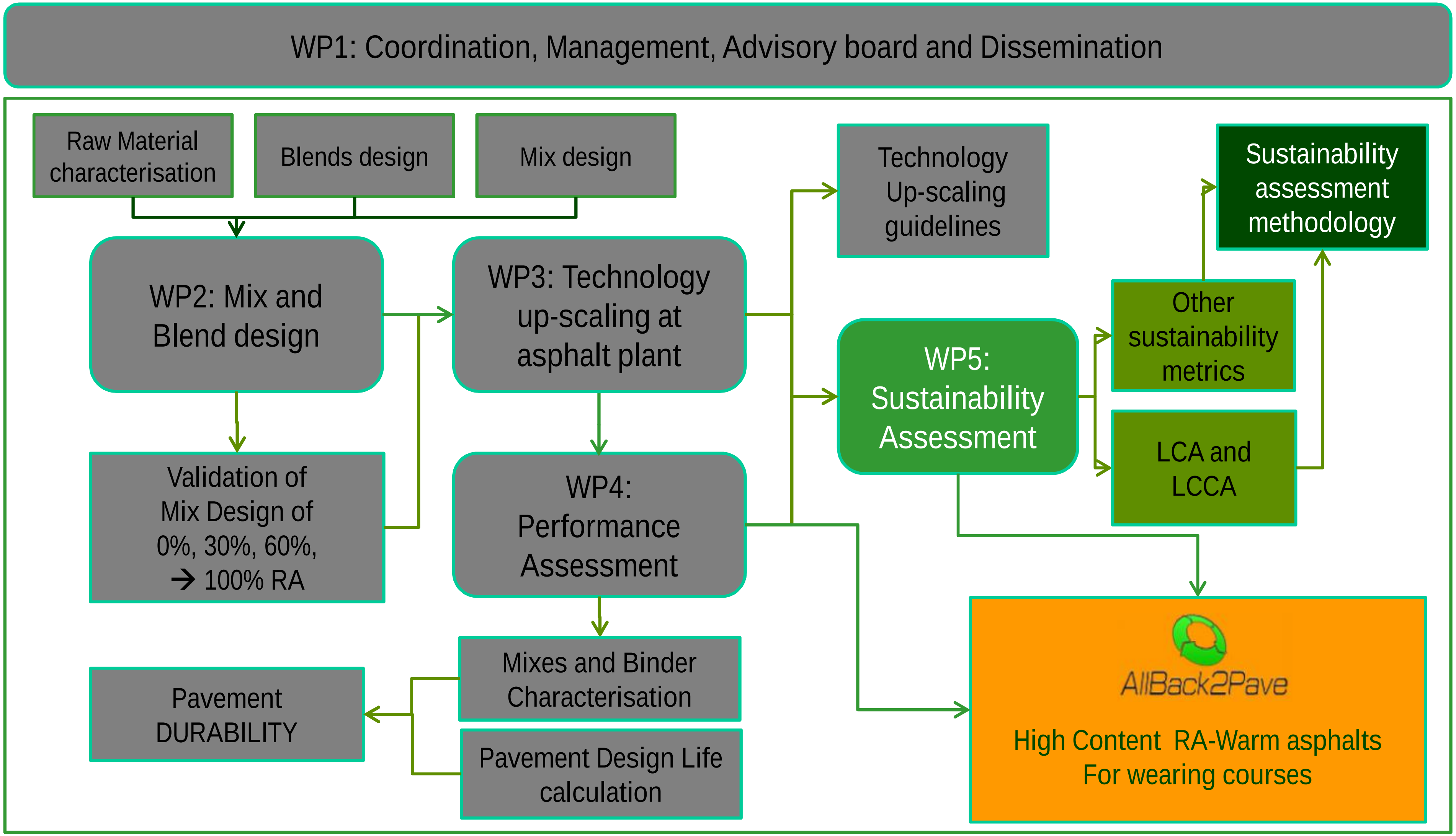
Maximise recycling

Minimise impact

- Sustainability metrics
- Performance based evaluation
- Life Cycle Assessment (LCA)
- Life Cycle Cost Analysis (LCCA)

Sustainability Assessment

WP5 – Sustainability assessment



WP5 – Sustainability assessment

WP5 Deliverables

http://allback2pave.fehrl.org

D5.1 - **A state of the art review of sustainability assessment tools (10/2015)** of the impact of road pavement infrastructures. This will serve as a base for the development of the AllBAck2Pave sustainability assessment methodology

D5.2 - **Evaluation of the environmental impact (LCA) and economical impact (LCCA) (10/2015)** of the defined technology taking into account the European level of the project and adapted to real case studies

D5.3 - **Sustainability assessment of the AllBack2Pave technologies (10/2015)** adapted to real case studies at European level, through a methodology developed by this project and proposed for ease of use by CEDR members.

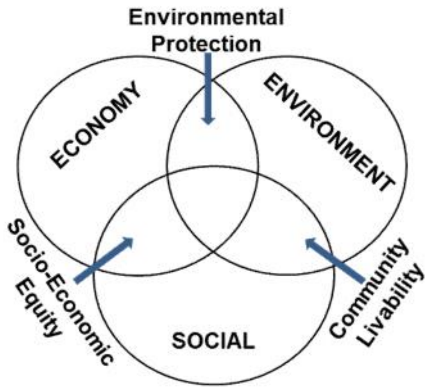
D5.1

State of the art review of sustainability assessment tools for roads

WP5 – Sustainability assessment

AllBack2Pave

Measuring "S" of Road Pavements



•**Mechanical Performance prediction** – WP4

•***The environmental performance*** of road pavement is generally assessed using life cycle assessment (LCA) tools

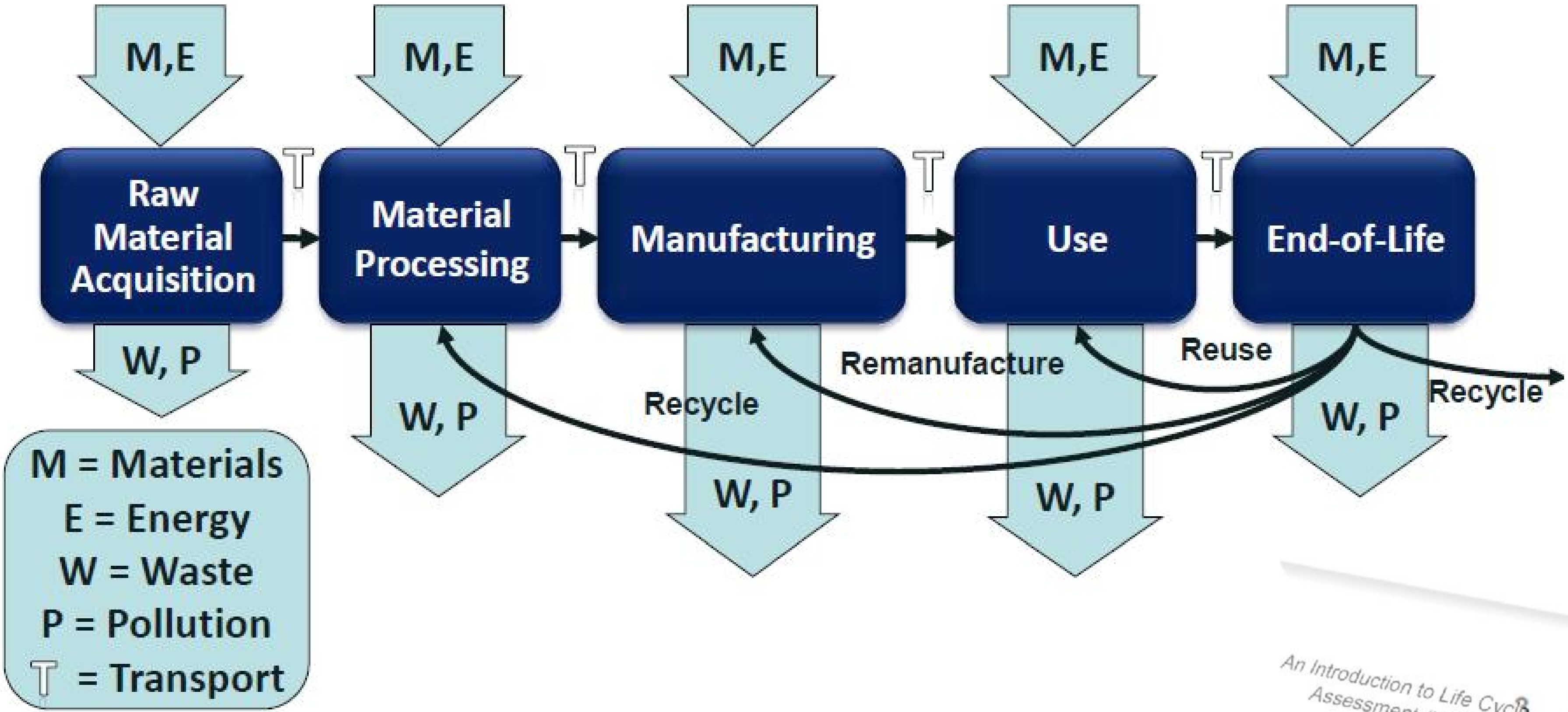
•**The economic aspect** is conducted using life cycle cost analysis (LCCA) or Life Cycle Cost (LCC) tools

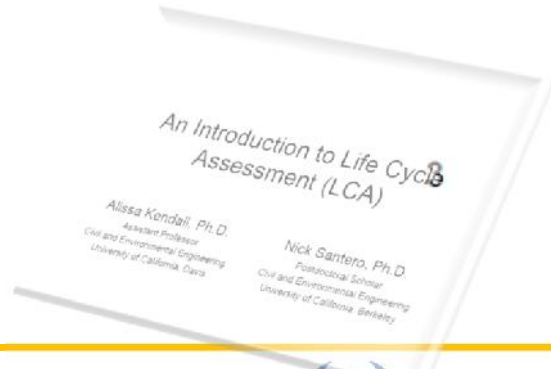
- **Other metrics** such as those to account for social aspect typically involves many stakeholders and ensure long-term goals of the community. However, metrics to measure social impacts associated with pavement systems are still not widely accepted

- **A sustainability rating system** is essentially a list of sustainability best practices with an associated common metric which provides measurement of road pavement sustainability (i.e. INVEST, GREENPAVE, BE^{2}ST)

Life Cycle Assessment (LCA)

in Transport Infrastructures Engineering





Life Cycle Cost Analysis (LCCA)

AllBack2Pave

in Transport Infrastructures Engineering

"…a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future cost, such as maintenance, user, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment."

Defined in Section 303, Quality Improvement, of the National Highway System NHS Designation Act of 1995

Modified by Transportation Equity Act for the 21st Century

What shall we measure "S" against?

AllBack2Pave

in Transport Infrastructures Engineering

UK Government Sustainable Development Indicators

- 68 indicators
- 20 framework indicators :

Greenhouse gas emissions	Employment
Resource use	Workless Households
Waste arisings	Childhood poverty
Bird populations	Pensioner poverty
Fish stocks	Education
Ecological impacts of air pollution	Health inequality
River quality	Mobility
Economic growth	Social justice
Community participation	Environmental equality
Crime	Wellbeing

SUP&R ITN
Sustainable Pavement & Railway
Internal Training Network

www.superitn.eu

LCE4 ROADS

http://ecolabelproject.eu/

http://www.defra.gov.uk/sustainable/government/progress/national/framework.htm

Sustainability Rating Systems

in Transport Infrastructures Engineering

<u>Infrastructures</u>

CEEQUAL (UK)

Envision (USA)

BREEAM Infrastructures (NL)

IS rating system (AUS)

<u>Road Infrastructures</u> <u>(*in use*)</u>

- GREENROADS (USA)
- FHWA INVEST (USA)
- I-LAST (IL, USA)
- GreenLITES (NYS, USA)

<u>Road Pavements</u> <u>(*in use*)</u>

- GreenPave (CA)
- BE2ST- In-Highway

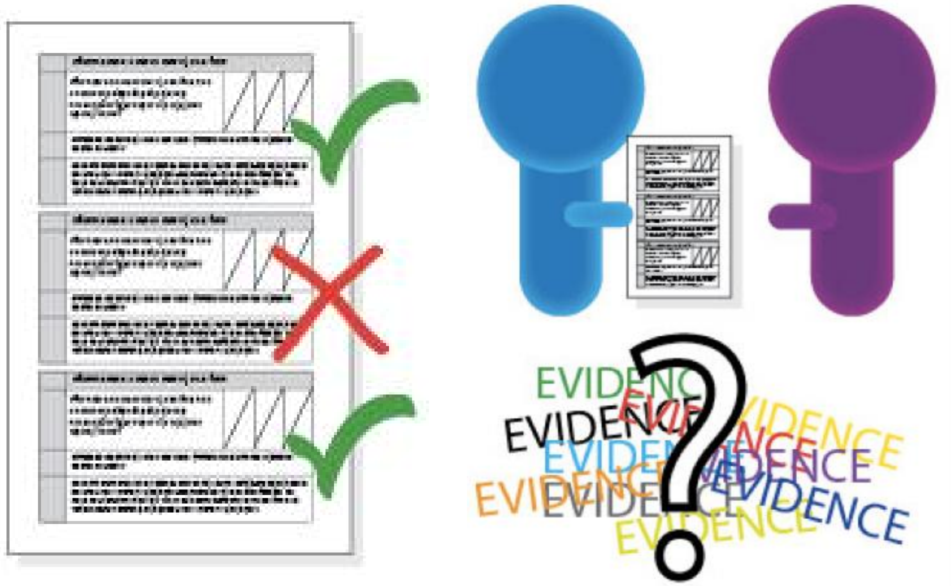
CEEQUAL

AllBack2Pave

CEEQUAL is the international evidence-based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and works in public spaces

CEEQUAL

IMPROVING SUSTAINABILITY



CEEQUAL features

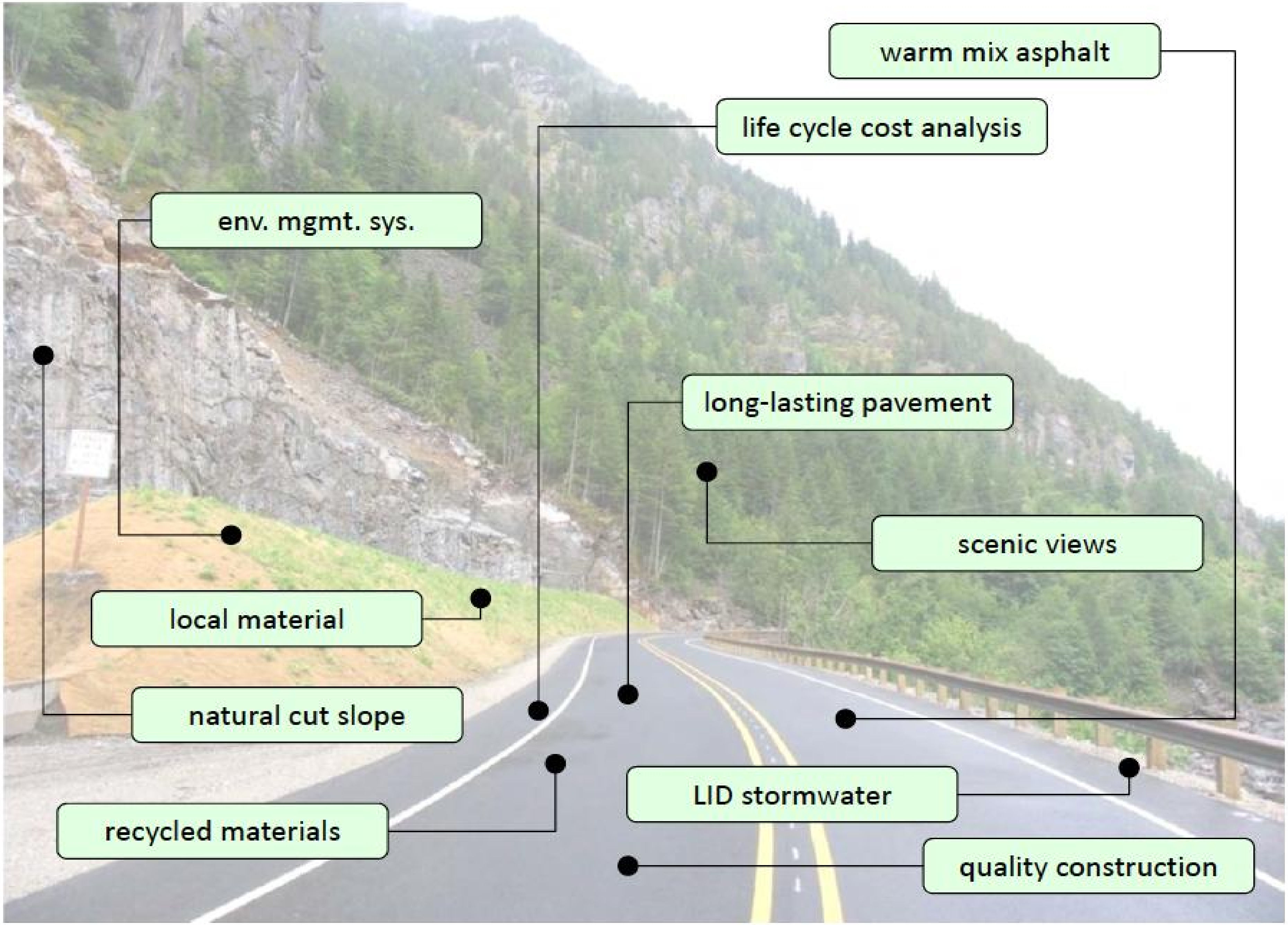
- Structured Third-party assessment
- It is made to have wider applications in Civil engineering
- Based on evidences
- Only qualitative assessment. No calculations involved
- Mainly working for evaluation of existing projects and can be used as useful check list in the planning and design stage
- Very hard to use for comparing different sustainable technologies for infrastructures

more sustainable roads for a better transportation future

Greenroads is a project-oriented system

It focuses on design and construction.

Greenroads


warm mix asphalt
life cycle cost analysis
env. mgmt. sys.
long-lasting pavement
scenic views
local material
natural cut slope
recycled materials
LID stormwater
quality construction

Project Requirements

Requirement		Description
PR-1	Environmental Review Process	Complete and environmental review process
PR-2	Life Cycle Cost Analysis (LCCA)	Perform LCCA for pavement section
PR-3	Life Cycle Inventory (LCI)	Perform LCI of pavement section with computer tool
PR-4	Quality Control Plan	Have a formal contractor quality control plan
PR-5	Noise Mitigation Plan	Have a construction noise mitigation plan
PR-6	Waste Management Plan	Have a formal plan to divert C&D waste from landfill
PR-7	Pollution Prevention Plan	Have a TESC/SWPPP
PR-8	Low-Impact Development (LID)	Feasibility study for LID stormwater management
PR-9	Pavement Mgmt. System	Have a pavement management system
PR-10	Site Maintenance Plan	Have a site maintenance plan
PR-11	Educational Outreach	Publicize sustainability information for project

Project Requirements (PR)			Y	N	?
	PR Subtotal:	11 Req'd			
PR-1	Environmental Review Process	Req			
PR-2	Lifecycle Cost Analysis	Req			
PR-3	Lifecycle Inventory	Req			
PR-4	Quality Control Plan	Req			
PR-5	Noise Mitigation Plan	Req			
PR-6	Waste Management Plan	Req			
PR-7	Pollution Prevention Plan	Req			
PR-8	Low-Impact Development	Req			
PR-9	Pavement Management System	Req			
PR-10	Site Maintenance Plan	Req			
PR-11	Educational Outreach	Req			

Environment & Water (EW)			Y	N	?
	EW Subtotal:	21			
EW-1	Environmental Management System	2			
EW-2	Runoff Flow Control	1 - 3			
EW-3	Runoff Quality	1 - 3			
EW-4	Stormwater Cost Analysis	1			
EW-5	Site Vegetation	1 - 3			
EW-6	Habitat Restoration	1 - 3			
EW-7	Ecological Connectivity	1 - 3			
EW-8	Light Pollution	3			

Access & Equity (AE)			Y	N	?
	AE Subtotal:	30			
AE-1	Safety Audit	1 - 2			
AE-2	Intelligent Transportation Systems	2 - 5			
AE-3	Context Sensitive Solutions	5			
AE-4	Traffic Emissions Reduction	5			
AE-5	Pedestrian Access	1 - 2			
AE-6	Bicycle Access	1 - 2			
AE-7	Transit & HOV Access	1 - 5			
AE-8	Scenic Views	2			
AE-9	Cultural Outreach	1 - 2			

Construction Activities (CA)			Y	N	?
	CA Subtotal:	14			
CA-1	Quality Management System	2			
CA-2	Environmental Training	1			
CA-3	Site Recycling Plan	1			
CA-4	Fossil Fuel Reduction	1 - 2			
CA-5	Equipment Emission Reduction	1 - 2			
CA-6	Paving Emission Reduction	1			
CA-7	Water Use Tracking	2			
CA-8	Contractor Warranty	3			

Materials & Resources (MR)			Y	N	?
	MR Subtotal:	23			
MR-1	Lifecycle Assessment	2			
MR-2	Pavement Reuse	4 - 5			
MR-3	Earthwork Balance	1			
MR-4	Recycled Materials	1 - 5			
MR-5	Regional Materials	1 - 5			
MR-6	Energy Efficiency	5			

Pavement Technologies (PT)			Y	N	?
	PT Subtotal:	20			
PT-1	Long-Life Pavement	5			
PT-2	Permeable Pavement	3			
PT-3	Warm Mix Asphalt	3			
PT-4	Cool Pavement	5			
PT-5	Quiet Pavement	2 - 3			
PT-6	Pavement Performance Tracking	1			

Custom Credit (CC)			Y	N	?
	CC Subtotal:	10			
CC-X	*Custom Credit Title*	1 - 5			
CC-X	*Custom Credit Title*	1 - 5			

All 11 PR Met?				
Greenroads Total	118			

Greenroads

Credit Checklist

Award Level	Minimum Score	Criteria
Certified	32	All Project Requirements Met + 30-39% of the Voluntary Credit:
Silver	43	All Project Requirements Met + 40-49% of the Voluntary Credit:
Gold	54	All Project Requirements Met + 50-59% of the Voluntary Credit:
Evergreen	64	All Project Requirements Met + 60% or more of the Voluntary C

What is in the Manual?

- Each Project Requirement or Voluntary Credit has these:
  - Goal
  - Requirements to meet the credit intent
  - Documentation to submit
  - Supporting information
    - Suggested approaches and strategies
    - Examples
    - Potential issues
    - Research
    - Glossary
    - References
  - Relationships to related credits, sustainability components and measureable benefits

Greenroads

GREENROADS features

- Third-party assessment
- It is made specifically for road infrastructures
- Based on evidences
- Mix of qualitative assessment and basic calculations
- Mainly working for evaluation of existing projects and can be used as useful check list in the planning and design stage
- Not so flexible to be used for comparing sustainable pavement technologies

INVEST: Sustainability throughout the Transportation Lifecycle

INVEST
ECONOMIC • SOCIAL • ENVIRONMENTAL

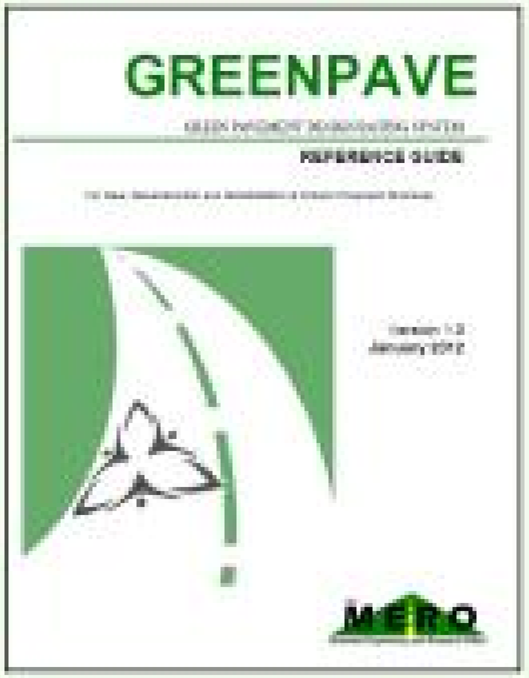
Affected Triple Bottom Line Principles

Voluntary • Private • Free • Flexible • Practical

GREENPAVE

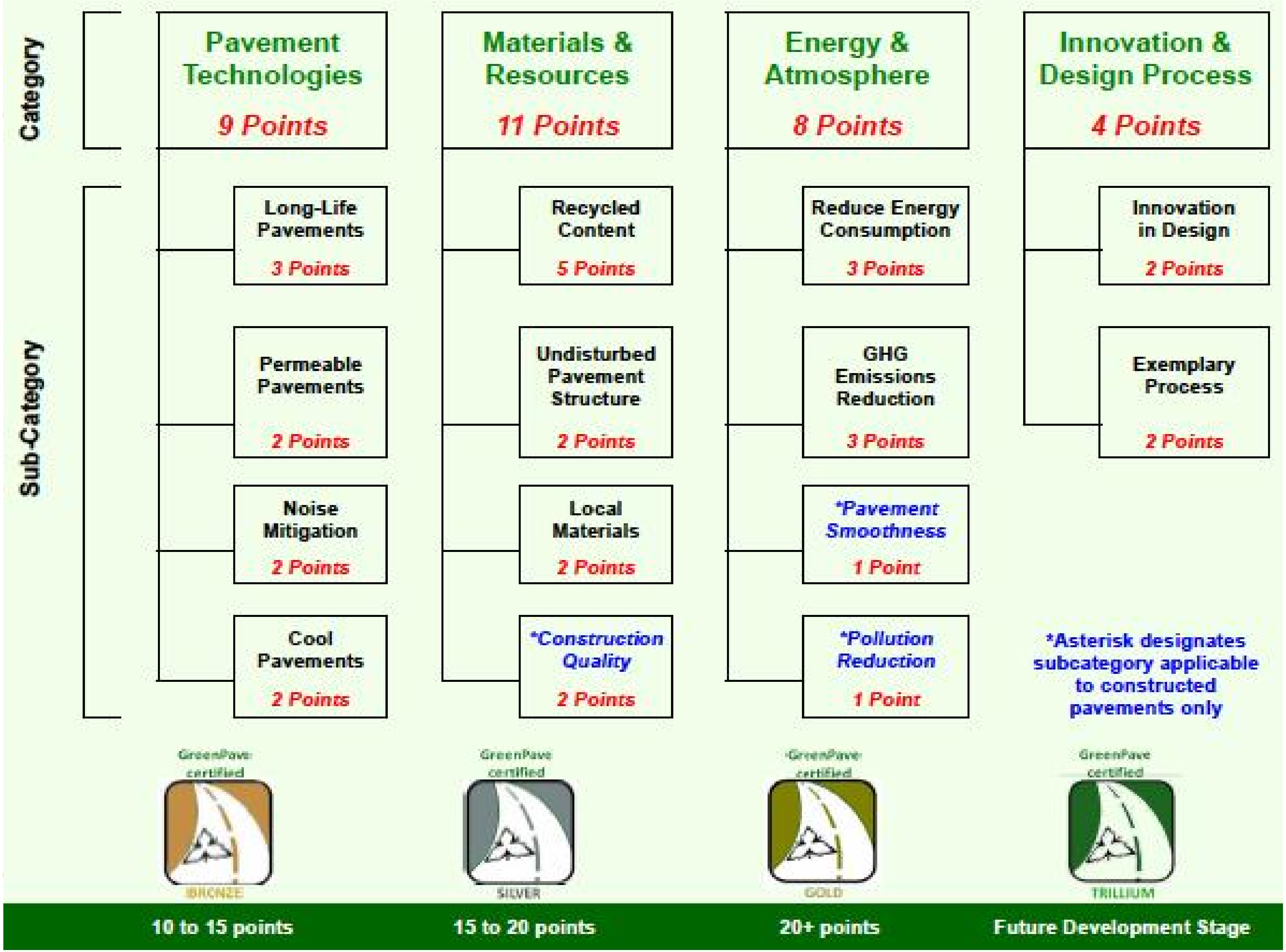
AllBack2Pave

GREENPAVE DOCUMENTS



MTO GreenPave Guideline

Snapshot of GreenPave Worksheet



Category
Sub-Category
Pavement Technologies
9 Points
Materials & Resources
11 Points
Energy & Atmosphere
8 Points
Innovation & Design Process
4 Points
Long-Life Pavements
3 Points
Permeable Pavements
2 Points
Noise Mitigation
2 Points
Cool Pavements
2 Points
Recycled Content
5 Points
Undisturbed Pavement Structure
2 Points
Local Materials
2 Points
*Construction Quality
2 Points
Reduce Energy Consumption
3 Points
GHG Emissions Reduction
3 Points
*Pavement Smoothness
1 Point
*Pollution Reduction
1 Point
Innovation in Design
2 Points
Exemplary Process
2 Points
*Asterisk designates subcategory applicable to constructed pavements only
GreenPave certified
BRONZE
GreenPave certified
SILVER
GreenPave certified
GOLD
GreenPave certified
TRILLIUM
10 to 15 points
15 to 20 points
20+ points
Future Development Stage

GREENPAVE example

AllBack2Pave

Pavement Technology (PT) - Max 9 Points

PT - 1: Long-Life Pavements (3 Points)

Is this Pavement Structure:

	Yes / No
Rigid Pavement	no
Composite Pavement	no
Perpetual Asphalt Pavement	no
Deep Strength Asphalt Pavement*	no

PT-1 Score = 0.0

PT - 2: Permeable Pavemenst (1-2 Points)

Are permeable pavements used in:

	Yes / No
Parking Areas or	no
Roadside Drainage or	no
Both	no

PT-2 Score = 0.0

PT - 3: Noise Mitigation (1-2 Points)

Surface Course is:

Asphalt	Yes / No
SuperPave	no
Stone Mastic Asphalt	yes
HMA w/ Rubber Mod AC	no
Quiet Pavement	no

Concrete	Yes / No
w/ Longitudinal Tining	no
w/ Diamond Grinding	no

PT-3 Score = 2.0

PT - 4: Cool Pavements (1-2 Points)

Surface Course is

Asphalt	Yes / No
Porous Asphalt	no
Quiet Pavement (ie, OGFC)	no

Concrete	Yes / No
Conventional	no
White Cement	no

Other	Yes / No
Permeable Pavers	no
Pervious Concrete	no

PT-4 Score = 0.0

GREENPAVE example

AllBack2Pave

Materials & Resources (MR) - Max 11 Points

				MR - 1 Recycled Content (1-5 Points)				MR - 3 Local Materials (1-2 Points)		MR - 4 Construction Quality (1-2 Points)	
	New Layer Type/ Treatment	Descriptions	Thickness (mm)	% of RAP, SCM, or RM	% of CR, RST, or Recycled Water	Point	Thickness x Point	% Aggregates (by mass) Transported within 100 km	Aggregates (w. r. t. thickness, mm) Transported within 100 km	Assigned Point from CA	Assigned Point from QAO
Layer 1	wearing course	inlay of wearing course	30	0%	0%	0	0	100%	30	0	0
Layer 2											
Layer 3											
Layer 4											
Layer 5											
Layer 6											
		Total Thickness =	30			Sum =	0	Sum =	30	MR-4 Score =	0.0
						MR-1 Score =	0.0	Total Aggregates Transported within 100 km (%) =	100%	Comments from CA:	
								MR-3 Score =	2.0	Comments from QAO:	

MR - 2: Undisturbed Pavement Structure (1-2 Points)

Does the rehabitiliation technique involve:

	Yes / No
Concrete Overlay	no
HMA Overlay, Chip seals Slurry Seals, Microsurfacing	no

Does the rehabilitation maintain the existing pavement structure?
If yes, complete the fields below:

		Thickness (mm)
Existing Pavement Structure, $t_{existing}$ =		510
Existing Structure will be processed or removed, $t_{processed}$ =	Minus	30
Exisiting Structure will be undisturbed or unprocessed, $t_{undisturbed}$ =		480
Additional Thickness will be placed on undisturbed structure, t_{place} =	Plus	30
New Pavement Structure, t_{new} =		510
Reuse Pavement, R = $t_{undisturbed}/t_{new}$ (%) =		94.1%
MR-2 Score =		2.0

Legend:
- CA = Contract Administrator
- CR = Crumb Rubber
- QAO = Quality Assurance Officer
- RAP = Reclaimed Asphalt Pavement
- Recycled Water = Treated Wash Water or Slurry Water
- RM = Recycled Material
- RST = Roof Shingle Tab
- SCM = Supplmentary Cement Material

GREENPAVE example

AllBack2Pave

Energy & Atmosphere (EA) - Max 8 Points

	New Layer Type/ Treatment	Description	Thickness (mm)	% of RAP, SCM, or RM	% of CR, RST, or Recycled Water	EA - 1: Reduced Energy Consumption (1-3 Points)		EA - 2: GHG Emission Reduction (1-3 Points)	
						Point	Thickness x Point	Point	Thickness x Point
Layer 1	wearing course	inlay of wearing course	30	0%	0%	0	0	0	0
Layer 2									
Layer 3									
Layer 4									
Layer 5									
Layer 6									
		Total Thickness	30			Sum =	0	Sum =	0
						EA-1 Score =	0.0	EA-2 Score =	0.0

EA - 3: Pavement Smoothness (1 Point)

What type of the surface course?

Answer:

If Asphalt Surface, what is the IRI value?

Answer:

EA-3 Score = 0.0

EA - 4: Pollution Reduction (1 Point)

What is the percentage of Construction Equipment/Vehicles with Emission Reduction Exhaust Retrofit or Fuel Efficient Technology?

Diesel Retrofit (%) = 0

Fuel Efficient Technology (%) = 0

EA-4 Score = 0.0

GREENPAVE example

AllBack2Pave

Innovation and Design Process (I) - Max 4 Points

I - 1: Innovation in Design (1-2 Points)

Any Innovation in Design? Answer: no

If Yes, what they are?

Innovation 1:

Innovation 2:

I-1 Score = 0.0

I - 2: Exemplary Process (1-2 Points)

Any Exemplary Process? Answer: no

If Yes, what they are?

Exemplary Process 1:

Exemplary Process 2:

I-2 Score = 0.0

GREENPAVE example

Maximum Point	GreenPave Category		Assigned Point							
			Baseline IT	SMA-IT RA30add	SMA-IT RA60add	SMA-IT RA90add	SMA-D RA30	SMA-D RA60	SMA-D RA60add	-
9	**Pavement Technologies**		**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**0.0**
3	Credit PT - 1	Long-Life Pavements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	Credit PT - 2	Permeable Pavements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	Credit PT - 3	Noise Mitigation	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
2	Credit PT - 4	Cool Pavements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
11	**Materials & Resources**		**4.0**	**7.0**	**8.0**	**9.0**	**7.0**	**8.0**	**8.0**	**0.0**
5	Credit MR - 1	Recycled Content	0.0	3.0	4.0	5.0	3.0	4.0	4.0	
2	Credit MR - 2	Undisturbed Pavement Struct	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
2	Credit MR - 3	Local Materials	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
2	Credit MR - 4	Construction Quaility	0.0	0.0	0.0	0.0	0.0			
8	**Energy & Atmosphere**		**0.0**	**4.0**	**4.0**	**6.0**	**4.0**	**4.0**	**4.0**	**0.0**
3	Credit EA - 1	Reduce Energy Consumption	0.0	2.0	2.0	3.0	2.0	2.0	2.0	
3	Credit EA - 2	GHG Emission Reduction	0.0	2.0	2.0	3.0	2.0	2.0	2.0	
1	Credit EA - 3	Pavement Smoothness	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	Credit EA - 4	Pollution Reduction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	**Innovation & Design Process**		**0.0**	**2.0**	**3.0**	**4.0**	**2.0**	**3.0**	**3.0**	**0.0**
2	Credit I - 1	Innovation in Design	0.0	1.0	2.0	2.0	1.0	2.0	2.0	
2	Credit I - 2	Exemplary Process	0.0	1.0	1.0	2.0	1.0	1.0	1.0	
32		**Total GreenPave Score:**	**6.0**	**15.0**	**17.0**	**21.0**	**15.0**	**17.0**	**17.0**	**0.0**
		Green Pave Rating:	NOT CERTIFIED	GOLD	GOLD	GOLD	GOLD	GOLD	GOLD	
		Life Cycle Cost:								

Bronze 9-12 points **Silver** 12-15 points **Gold** >15 points

GREENPAVE features

- SELF assessment scheme
- NOT Based on evidences
- It is made specifically for road pavements (based on GreenRoads)
- Mix of qualitative assessment and basic calculations
- Mainly working for evaluation of existing projects and can be used as useful check list in the planning and design stage
- Suitable for comparing sustainable pavement technologies

BE^{2}ST in Highway

AllBack2Pave

Building Environmentally and Economically Sustainable Transportation-Infrastructure-Highways™

(BE^{2}ST-in-Highways™)

Recycling Materials Resource Center/University of Wisconsin-Madison

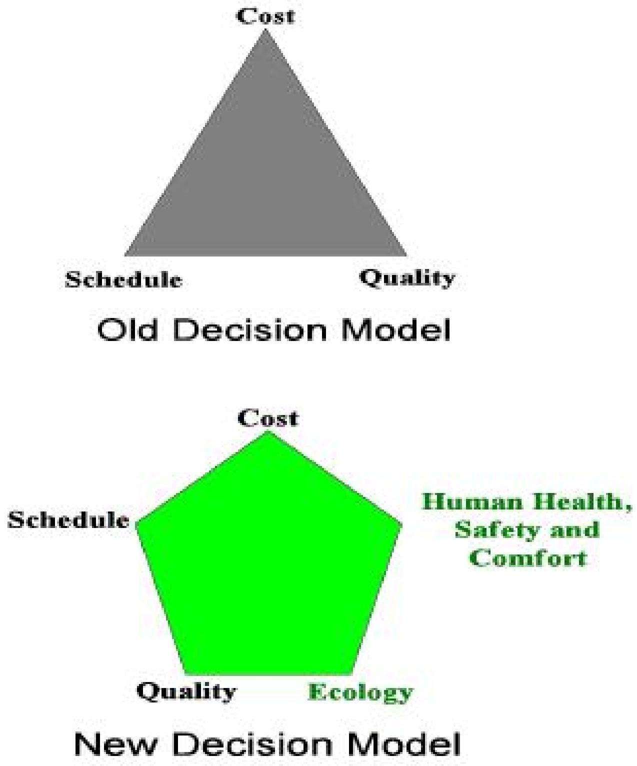
BE^{2}ST in Highway

- **As an action item of *Agenda 21***

  Promote the increased use of energy-efficient designs and technologies in an economically and environmentally appropriate way (construction industry: activities 7.69 (c))

- **Other key definitions** (Kibert, Gambatese, etc.)
  - 3 Rs (Reduce, Reuse, Recycle)
  - Reduce waste and emission
  - Increase health and safety

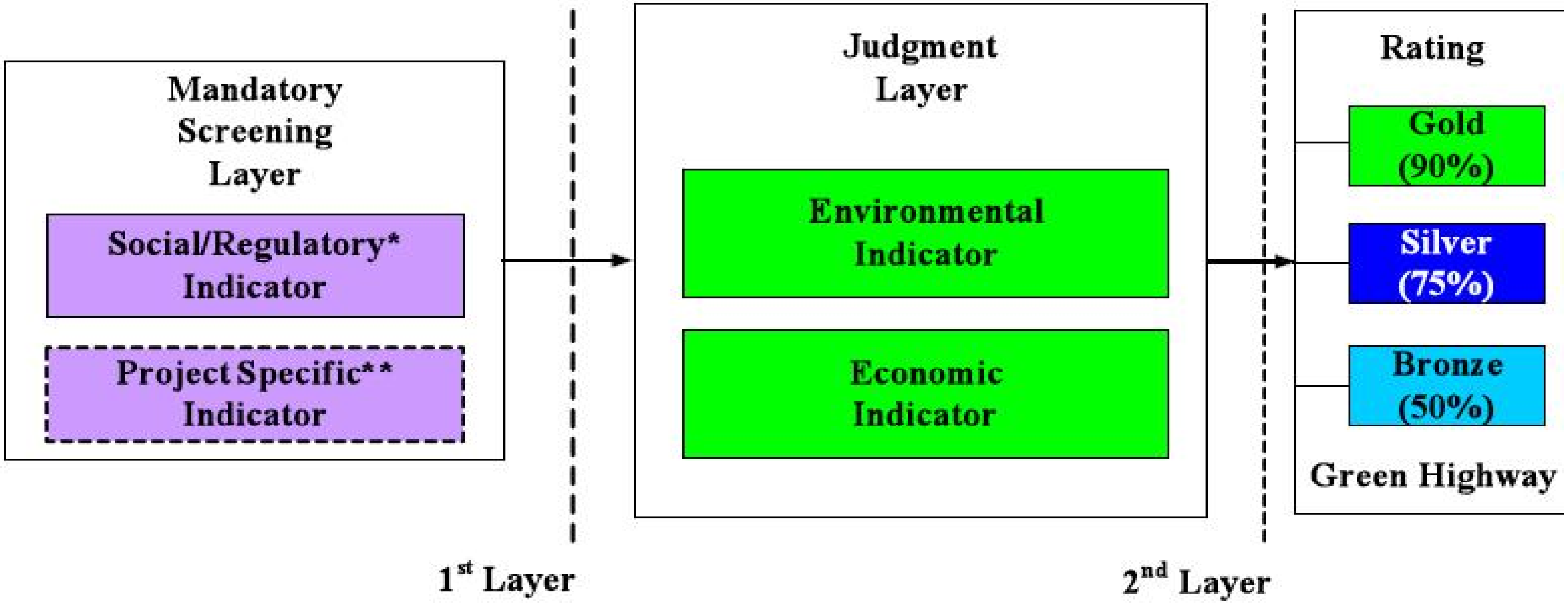
Paradigm Shift
(Mendler and Odell 2000)



From: Tuncer B. Edil, "Building Environmentally And Economically Sustainable Transportation Infrastructure in Highways (BE2ST-in-Highways)

BE^{2}ST in Highway

AllBack2Pave

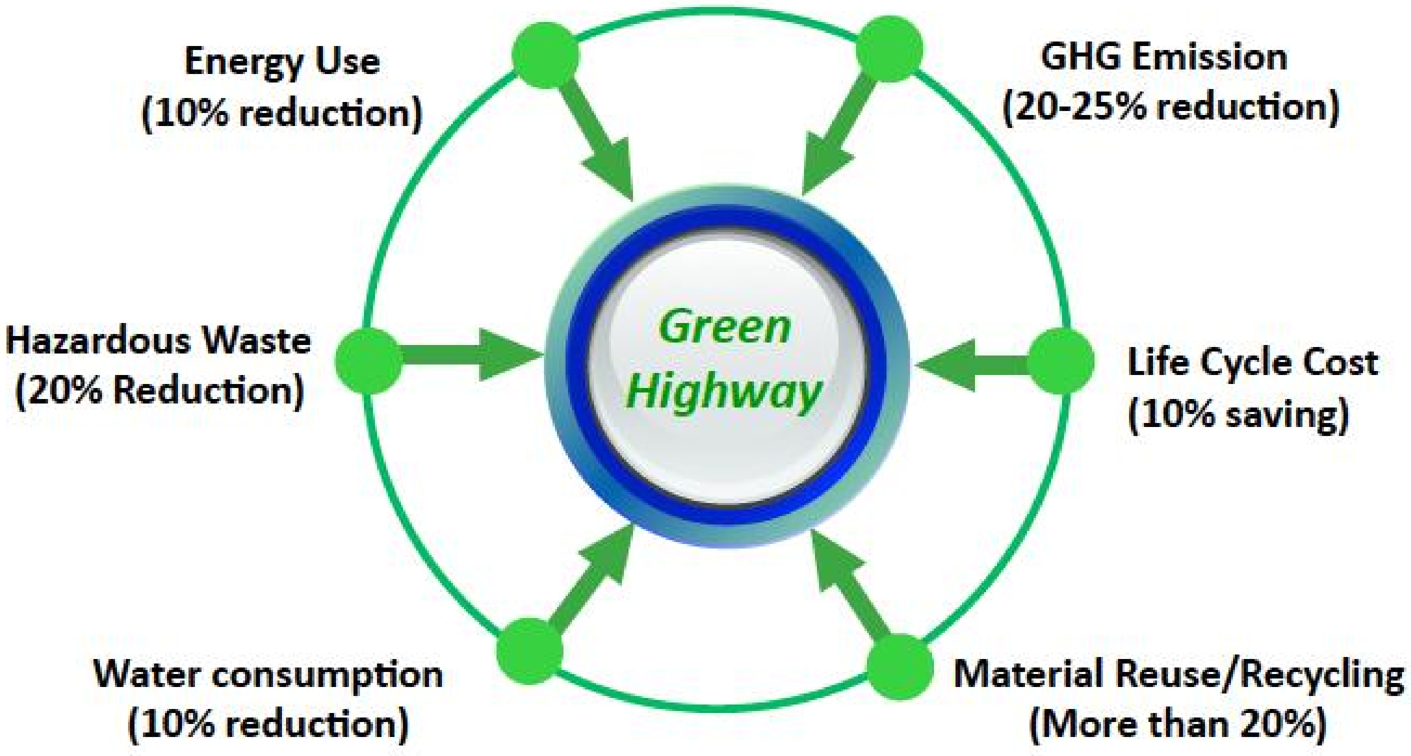


* User needs, laws, local ordinances, and quality requirement

** Preservation of historic site and schedule requirement

From: Tuncer B. Edil, "Building Environmentally And Economically Sustainable Transportation Infrastructure in Highways (BE2ST-in-Highways)

BE^{2}ST in Highway



From: Tuncer B. Edil, "Building Environmentally And Economically Sustainable Transportation Infrastructure in Highways (BE2ST-in-Highways)

BE^{2}ST in Highway

AllBack2Pave

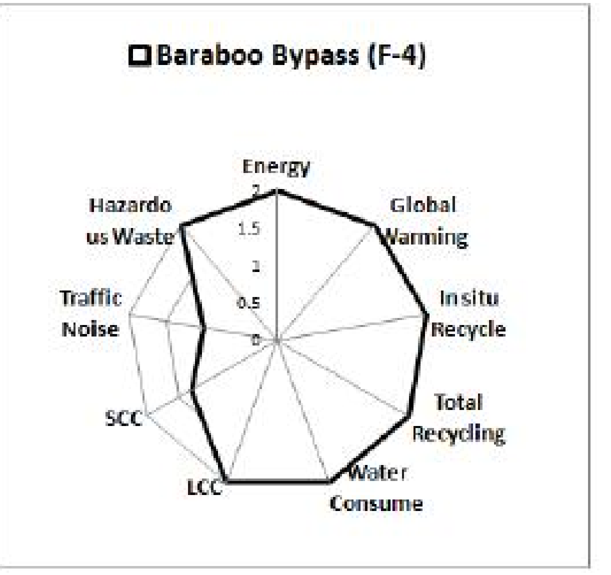
Summary of Rating

Execution

Project Name:	Baraboo Bypass (F-4)
State Route:	US-12
Length:	1 mile
Unit SCC	$69/Mg-CO2

Criteria	Target	Reference	Alternative	Performance
Energy Use (MJ)	>= 10% Reduction (1 pt) >= 20% Reduction (2 pt)	16,953,724	9,674,923	42.93%
GWP (Mg)	>= 10% Reduction (1 pt) >= 20% Reduction (2 pt)	884	506	42.84%
In Situ Recycling (CY)	>= 10% Recycling Rate (1 pt) >= 20% Recycling Rate (2 pt)	0.00	1302.40	36.20%
Total Recycling (CY)	>= 10% Recycled Content (1 pt) >= 20% Recycled Content (2 pt)	0.00	1769.78	49.18%
Water Consumption (kg)	>= 5% Reduction (1 pt) >= 10% Reduction (2 pt)	4,702	2,660	43.42%
Life Cycle Cost ($)	>= 5% Reduction (1 pt) >= 10% Reduction (2 pt)	$2,121,147	$983,868	53.62%
Social Carbon Cost ($)	>= $19,750/mi Saving (1 pt) >= $39,500/mi Saving (2 pt)	$60,996	$34,914	$26,082
Traffic Noise (no unit)	HMA (1 pt) SMA or OGFC (2 pt)	-	1	1
Hazardous Waste (kg)	>= 10% Reduction (1 pt) >= 20% Reduction (2 pt)	181,991	104,348	42.66%

Accomplished Score	90.69
Awarded Label	Green Highway Gold



Title | Rating summary | M-EPDG | Weighting | PaLATE | LCCA | Traffic Noise | Stormwater | Sheet1

SMA: Stone Matrix Asphalt
OGFC: Open Graded Friction Courses

BE²ST features

- Made for comparing sustainable pavement technologies
- SELF assessment scheme
- NOT Based on evidences
- It is made specifically for road pavements (based on GreenRoads)
- Entirely quantitative assessment bases on pre-defined target and weighting
- Working for evaluation of existing projects but also at planning and design stage

D5.1 Conclusions and suggestions

AllBack2Pave

- Sustainability Rating Systems (SRS) are usually qualitative based, although few recent tools are defined for a quantitative assessment of the metrics
- **SRS are helping in raising awareness on sustainability within the transport infrastructure industry**
- A third-party assessment system (No-profit business) allows SRS to have higher impact on behaviour changing, however self-assessment is a good first step

D5.1 Conclusions and suggestions

AllBack2Pave

- **A European/CEDR sustainability assessment methodology for road pavement is needed.**
- SRS are all voluntary systems. Behaviour change is more likely to happen if Infrastructure authorities (managers) will make them mandatory
- Flexible, User-friendly framework mainly based on quantitative measurements and with suggested EU free tools

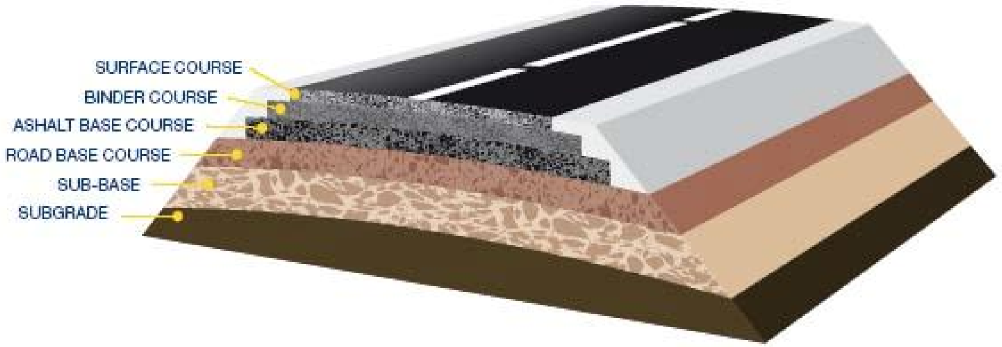
D5.1 Conclusions and suggestions

AllBack2Pave

Pavement Design:

- Pavement structure
- Design Life/Mechanical performance prediction
- M & R strategies

Final Design



Bad?

Sustainability Assessment

- Sustainability Performance prediction and rating

Good

AllBack2Pave

Reccomendations for D5.2

AllBack2Pave

AllBack2Pave *Sustainability assessment methodology*

- Sustainability assessed through **comparative assessment** with one or more design alternatives (i.e. current local practice)
- **Based on EU case studies** (real projects) with data from the interested Road Authorities
- Environmental impact with possibly full **LCA/Carbon foot printing. Economic impact with LCCA**

Reccomendations for D5.3

AllBack2Pave

AllBack2Pave *Sustainability assessment methodology*

- **Use both** the GreenPave and BE^{2}ST approach to sustainability rating of the outcomes of this project, on identified case studies.
- **Review the criteria** in GreenPave and BE^{2}ST and decide if they are the most relevant to our exercise and eventually adapt those identified as not suitable to the European and/or local context of the analysed case studies
- **Review European freely available tools** to account for sustainability performance of road pavements, and draw recommendations for their future use within a CEDR sustainability rating system.

from D5.2

Environmental performance prediction of the AB2P technologies

D5.2 - Environmental impact of the AB2P Technologies

AllBack2Pave

DATA COLLECTION

- Questionnaires to Road Authority and Asphalt plants
- Literature
- Software database

CASE STUDY

- Baseline scenario: locations, traffic, pavement structure, etc.
- Lifetime maintenance strategy
- Other assumptions for LCA and LCCA

IMPACT ASSESSMENT

- Environmental Impact: LCA/ Carbon footprinting

Case Studies

AllBack2Pave

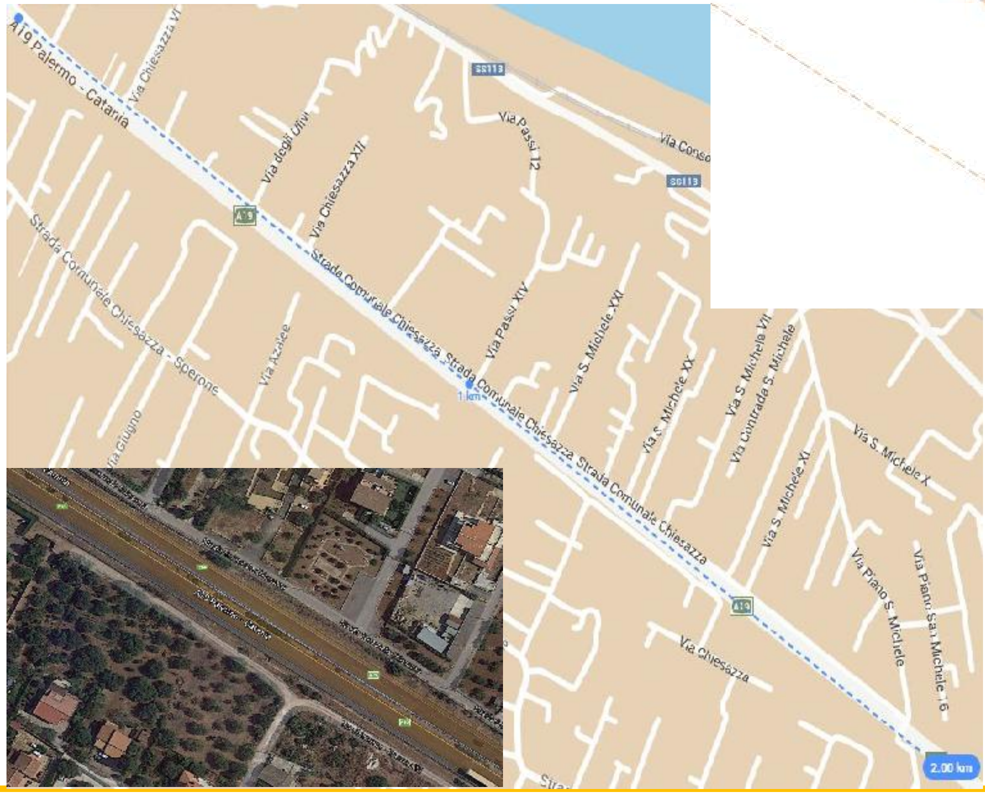
Maintenance treatment	• Surface treatments with periodic inlay of wearing course and occasional inlay of binder and base course • Maintenance is undertaken in one carriageway (two lane), or one lane (single lane road) at a time, with the traffic diverted onto the other carriage/lane. • Workzones are extended for the whole length and the width of the full carriageway. • In the case studies with dual carriageway, maintenance event is considered only in one direction.

Materials	Current asphalt mixtures for each case study will be compared with the following asphalt mixes for wearing course and occasionally binder and base course: AB2P SMA mixes technologies 1. SMA D-RA30 2. SMA D-RA60 3. SMA D-RA60add 4. SMA IT-RA30add 5. SMA IT-RA60add 6. SMA IT-RA90add

Case Studies

South EU: Italy

High Traffic



A19 between Junctions “Altavilla” and “Trabia”, Palermo, (PA), *Italy*

Case Studies

AllBack2Pave

South EU: Italy

High Traffic

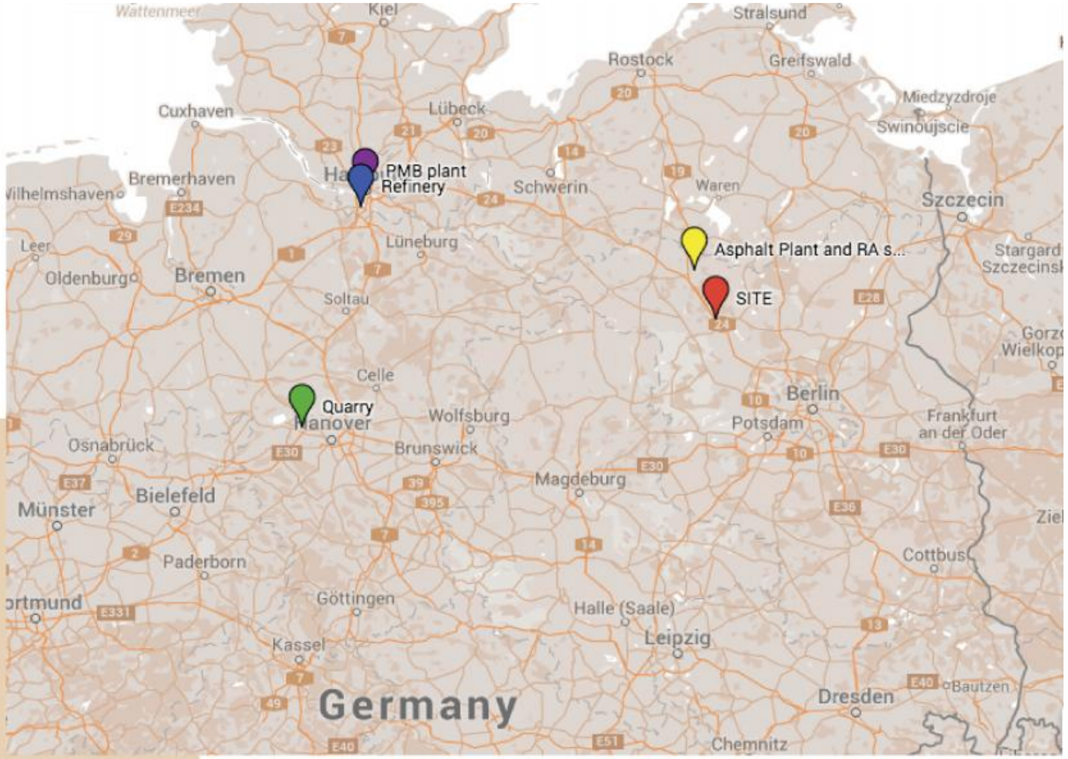
A19 between Junctions “Altavilla” and “Trabia”, Palermo, (PA), *Italy*

	Origin	Mode of transport	One way distance (km)
South Europe – Palermo, Italy			
Virgin aggregates 0.075 – 20 mm	Quarry	Rigid>17t, 20t payload	46
Filler <0.075 mm	Plant	-	0
RA Planings	RA stockpile	Rigid>17t, 20t payload	32
Bitumen/PMB	Refinery	Rigid>17t, 20t payload	215
Fibers	ITERCHIMICA Bergamo, IT	Articulated >33 t, 24 t payload	1370
STORBIT PLUS additive	STORIMPEX Leipzig	Articulated >33 t, 24 t payload	2250

Case Studies

Central EU: Germany

Medium Traffic



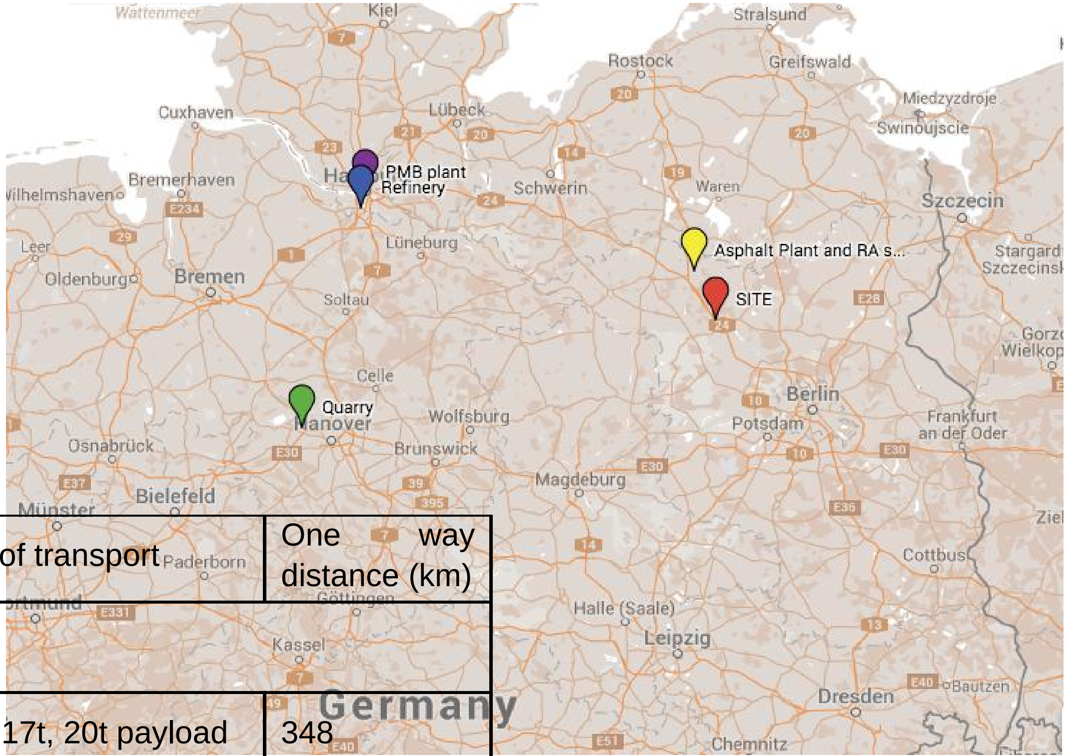
A24 near Neuruppin north-west of Berlin, Germany

Case Studies

Central EU: Germany

Medium Traffic

A24 near Neuruppin north-west of Berlin, Germany



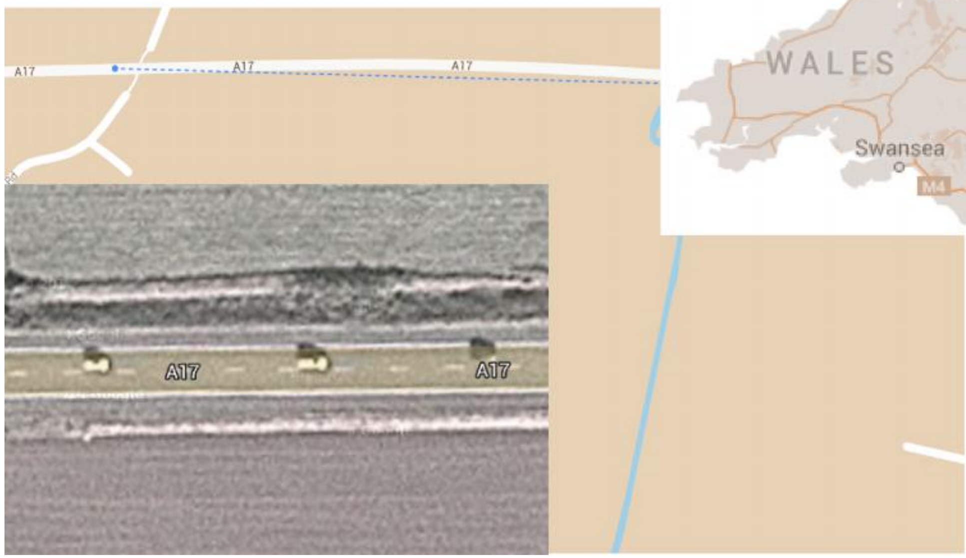
	Origin	Mode of transport	One way distance (km)
Central Europe – Wittstock, Germany			
Virgin aggregates 0.075 – 20 mm	Quarry	Rigid>17t, 20t payload	348
Filler <0.075 mm	Plant	-	0
RA Planings	RA stockpile	Rigid>17t, 20t payload	35
Bitumen/PMB	Refinery	Rigid>17t, 20t payload	215
Fibers	Central Germany	Articulated >33 t, 24 t payload	623
STORBIT PLUS additive	STORIMPEX Hamburg	Rigid>17t, 20t payload	180

Case Studies

AllBack2Pave

North EU: United Kingdom

Low Traffic



A17 Lincolnshire, between Sutton Bridge and King's Lynn

CEDR
Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

North EU: United Kingdom

Low Traffic

A17 Lincolnshire, between Sutton Bridge and King's Lynn

	Origin	Mode of transport	One way distance (km)
North Europe – Lincoln, UK			
Virgin aggregates 0.075 – 20 mm	Quarry	Rigid>17t, 20t payload	70
Filler <0.075 mm	Plant	-	0
RA Planings	RA stockpile	Rigid>17t, 20t payload	70
Bitumen/PMB	Refinery	Rigid>17t, 20t payload	160
Fibres	Central Europe (RE-ROAD 2012)	Articulated >33 t, 24 t payload	375
STORBIT PLUS additive	STORIMPEX Hamburg	Articulated >33 t, 24 t payload (overestimated by not including the rail freight channel tunnel)	1160

Case Studies

Pavement course	South EU - IT (ANAS 2015)	Central EU - D (BASt 2015)	North EU - UK (Spray 2014)
Section Width	9.50m	11.80m	11.00m
Section Length	2000m	800m	720m
Wearing	Asphalt 30 mm	Asphalt 30 mm	Asphalt 40 mm
Binder	Asphalt 40 mm	Asphalt 80 mm	Asphalt 50 mm
Base	Asphalt 100 mm	Asphalt 140 mm	Asphalt 100 mm
Foundation	Cement treated sand 300 mm	Unbound layer gravel +frost blanket 350 mm	Cement treated limestone 258 mm
Traffic levels	High Traffic	Medium Traffic	Low Traffic
Typical Durability of wearing course	5 years	16 years	10 years
Typical Durability of binder course	20-30 years		
Typical Durability of base course	40-50 years		

Mainteinance Scenarios

Analysis period	60 years					
Country dependent maintenance strategy	*Italy:* (ANAS 2015)		*Germany:* (BASt 2015)		*UK:* (Spray 2014)	
	year	*procedure*	*year*	*procedure*	*year*	*procedure*
	0 - 5	Inlay WC+BC	0 - 16	Inlay WC+BC	0 - 10	Inlay WC+BC
	5 - 10	Inlay WC	16 - 28	Inlay WC	10 - 20	Inlay WC
	10 - 15	Inlay WC	28 - 44	Full Depth Reclamation	20 - 30	Inlay WC+BC
	15 - 20	Inlay WC	44 - 60	Inlay WC	30 - 40	Inlay WC
	20 - 25	Inlay WC			40 - 50	Full Depth Reclamation
	25 - 30	Inlay WC+BC			50 - 60	Inlay WC
	30 - 35	Inlay WC				
	35 - 40	Inlay WC				
	40 - 45	Inlay WC				
	45 - 50	Inlay WC				
	50 - 55	Full Depth Reclamation				
	55 - 60	Inlay WC				

Environmental impact of AB2P t.

AllBack2Pave

Carbon footprint of the asphalt mixes
[KgCO2e/t]

Maintainance scenarios of EU typical interurban road pavements over the analysys period (60 years)

Environmental impact of the asphalt mixes over the analysis period
[ton CO2e], [ton CO2e/Km]

CO_2e

asPECT

asphalt Pavement Embodied Carbon Tool

Carbon Footprinting/LCA

AllBack2Pave

Goal and Scope

The goal of this investigation is to conduct a **process cradle-to-laid + EOL comparative LCA of the proposed AB2P technologies**, to be used as replacements of the current asphalt wearing courses in each of the presented case studies.

Functional Unit

The chosen functional unit is generally the **weight, express in tons, of asphalt mixtures to be manufactured and used during the inlay procedures of the selected case studies.** The tons of asphalt to be replaced in the case study were calculated by multiplying the volume of each wearing course, multiplied for an estimated density of 2.3 t/m^3.

Carbon Footprinting/LCA

Reference Service Life

The RSL shall refer to the declared technical and functional performance of the product within a building (EN 15804:2012 2012).

In this exercise **RSL was provided directly from the interested road authorities** or obtained from literature (Table 9) and it will be considered equal for all the considered asphalt mixes.

	South EU (ANAS 2015)	*Central EU* (BASt 2015)	*North EU* (Spray 2014)
Wearing course	5 years	16 years	10 years
Binder course	20-30 years		
Base course	40-50 years		

Carbon Footprinting/LCA

AllBack2Pave

System Boundaries (1 service life)

PRODUCT
- Resources acquisition (to the plant)
- Asphalt mixes Manufacturing (at the plant)

CONSTRUCTION
- Asphalt mixes Installation in road pavement (at the site)

USE (within service life)
- Interaction with Environment (albedo, etc..)
- Interaction with Users (fuel consumption)
- minor Road Managers operations (patching, etc)

END-OF-LIFE (end of service life)
- Excavation and Stockpiling (inlay, rehabilitation, etc.)

ISO 14040:2006 - Environmental management -- Life cycle assessment -- Principles and framework

ISO 14044:2006 - Environmental management -- Life cycle assessment -- Requirements and guidelines

EN 15804:2012. "EN 15804:2012 - Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method." 2012.

Carbon Footprinting/LCA

Results (1 service life): *Cradle-to-laid + EOL CF of the considered AB2P asphalt mixes for wearing course and variations with respect to the currently used mixes (baselines)*

	South EU (Italy) (kgCO2e/t)		*Central EU (Germany)* (kgCO2e/t)		*North EU (UK)* (kgCO2e/t)	
Baseline	93.1	-	105.3	-	72.9	-
SMA 16-RA30add	92.9	-0.2%	82.1	-22.3%	64.4	-11.7%
SMA 16-RA60add	90.5	-2.8%	68.2	-35.2%	62.3	-14.5%
SMA IT-RA90add	88.2	-5.3%	54.8	-48.0%	60.5	-17.0%
SMA D-RA30	102.3	9.9%	91.1	-13.5%	73.7	1.1%
SMA D-RA60	95.0	0.0%	74.3	-29.4%	67.1	-8.0%
SMA D-RA60add	99.0	0.2%	77.3	-26.6%	70.6	-3.2%

*From an overall analysis of the results, it is possible to affirm that **using the asphalt mixes with high RA content generally provides similar or lower carbon footprint than the asphalt mixes currently used in Europe.***

Carbon Footprinting/LCA

AllBack2Pave

Results (1 service life): *Cradle-to-laid + EOL CF of the AB2P asphalt mixes*

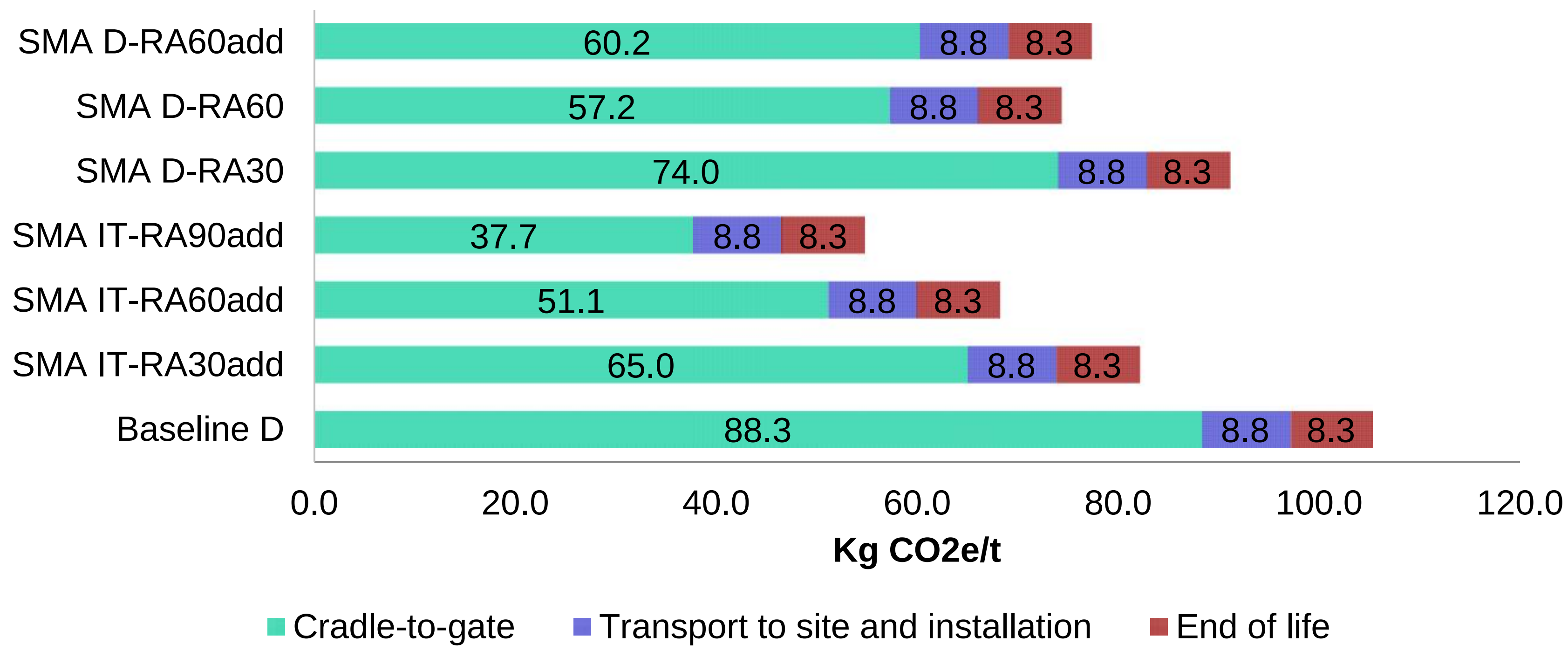
The differences between the case studies can be summarized as follows:

- The South EU case study shows **highest values because of the longest distances for transportation of mixes from the plant to site and from the site to the stockpile.**
- Central EU case study accounts for higher variation from the baseline (RA 0%) because the **distance of the virgin aggregate quarry from the asphalt plant is 10 times higher than the distance to the RA stockpile**
- North EU study **shows that maintaining transport distances of aggregates, RA and worksite below 100 Km from the asphalt plant**, **obtains the average lowest emission**

Carbon Footprinting/LCA

Results (1 service life): LIFECYCLE HOTSPOTS

kg CO2e/t contribution of the life cycle steps to the overall footprints for the Central EU case study

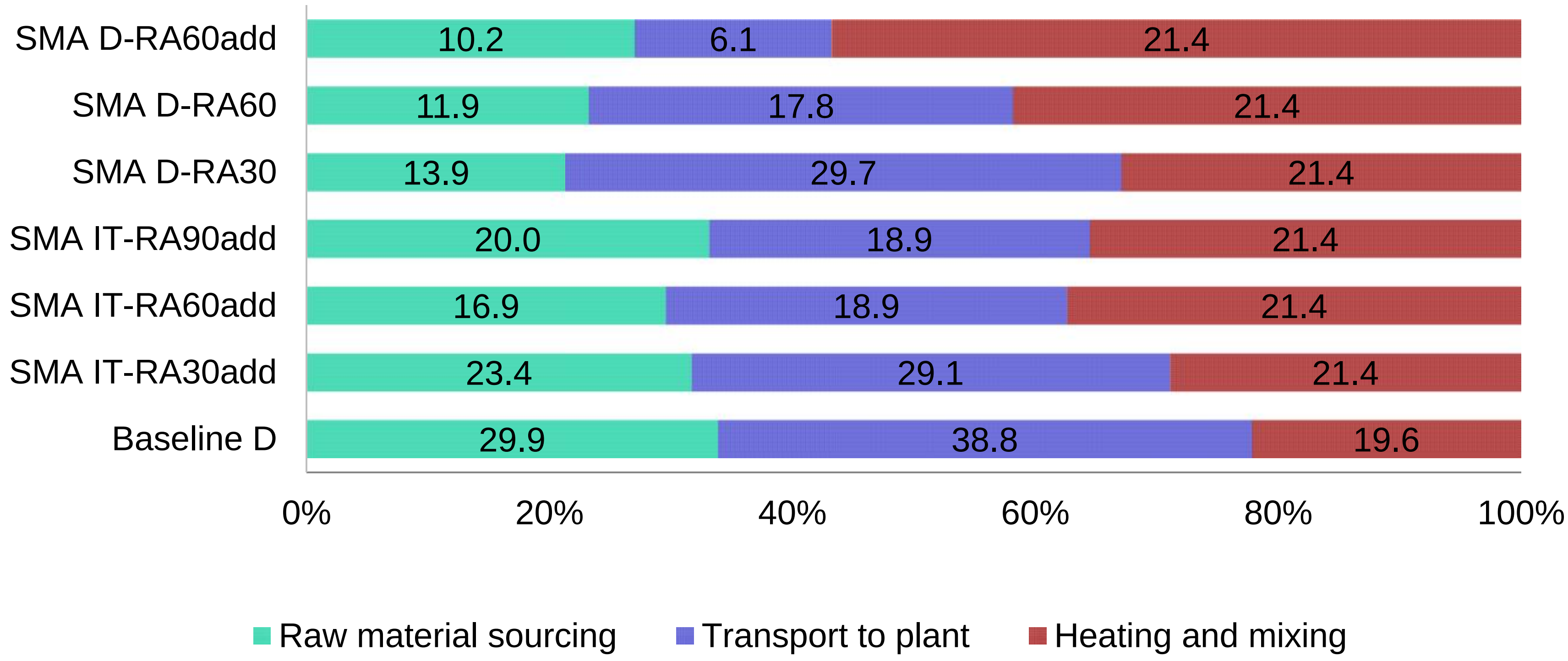


Carbon Footprinting/LCA

AllBack2Pave

Results (1 service life): LIFECYCLE HOTSPOTS

Contribution of each operation to the cradle-to-gate stage for the Central EU case study.



Carbon Footprinting/LCA

AllBack2Pave

Results (1 service life): LIFECYCLE HOTSPOTS

In the Central EU case study:

- the main contribution to the emissions is due to transport distances from the asphalt mix components' sources to the asphalt plant.

- In this case therefore, an improvement to reduce emissions would consist in minimising transport distances. In particular the virgin aggregate source could be chosen closer to the asphalt plant.

Mainteinance Scenarios

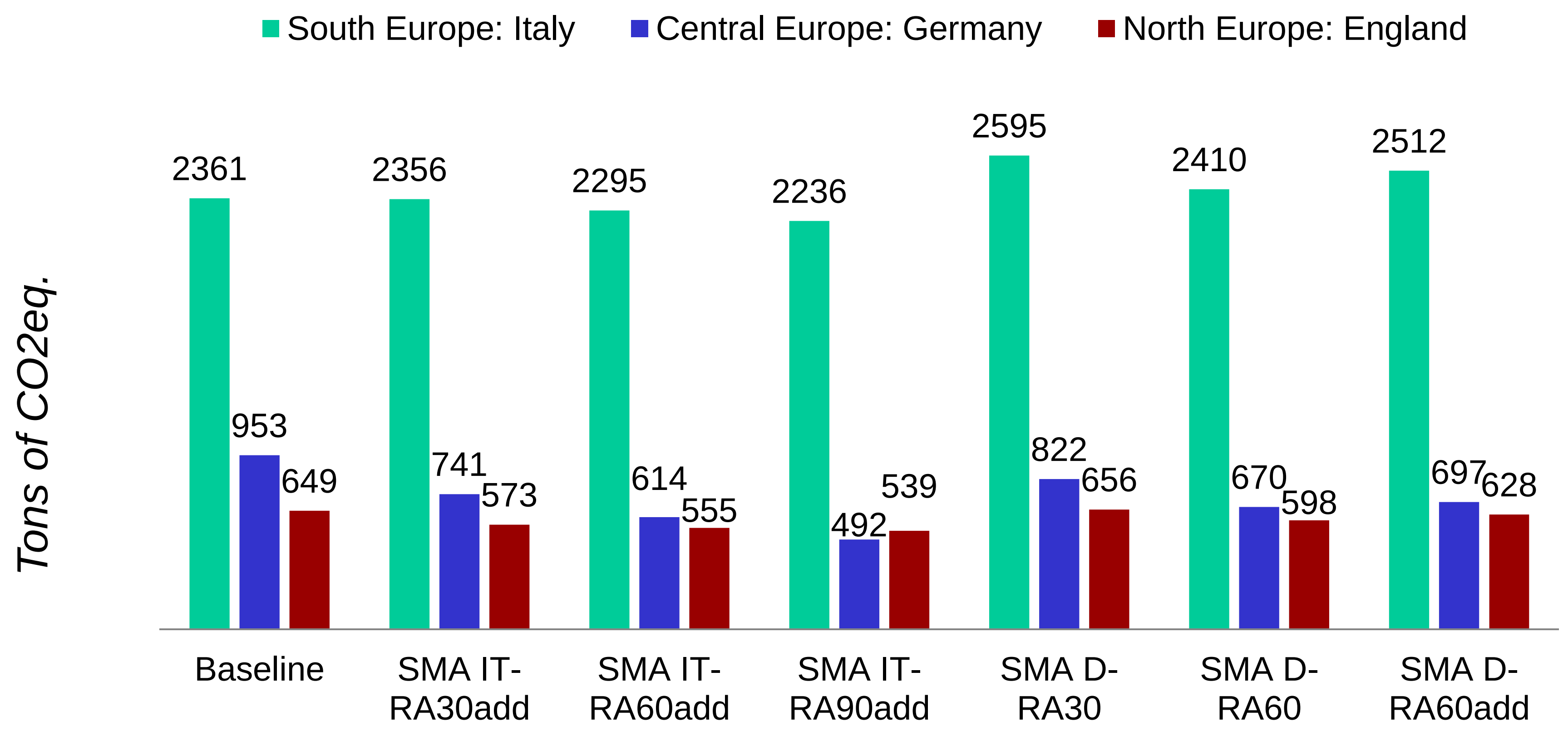
Number of interventions per case study over the 60 years

	South EU - IT	Central EU - D	North EU - UK
Inlay WC	9	2	2
Inlay WC + BC	2	1	2
Full Depth Reclamation	1	1	1
TOTAL	**12**	**4**	**5**

N.B. For ease of comparison, whenever the M&R scenarios includes other layers, it is assumed that those layers are build with the same asphalt mixes used for the wearing course

Environmental impact of AB2P t.

over analysis period (60 years)



Environmental impact of AB2P t.

AllBack2Pave

over analysis period (60 years)

In all case study the AB2P mixes bring an overall advantage in terms of CO2e footprint that is proportional to the amount of RAP used in the mix.

- In South EU case study with this maintenance strategy/wearing course durability, the effect of maximising the amount of recycled material seems to be minimal. **It can be deduced then, that any improvement in the lifetime of this layer can bring significant benefits to the environment.**

- The Central EU case study shows that using the AB2P mixes the overall carbon footprint decreases when the RA content increases. In fact, in this case study, the wearing course durability is the highest and therefore, **more than the other case studies, the amount of recycled content plays a significant role.**

- The North EU case study on average shows the lowest environmental impact despite it has more interventions than the Central EU case study. Furthermore, it shows up to 15% reduction of emissions due to increase of RA content, so **it is possible to conclude that there are no specific advices to improve the maintenance strategy for this case study.**

Conclusions and developments

AllBack2Pave

- **Asphalt mixes with high RA content generally provides similar or lower carbon footprint than the asphalt mixes currently used in Europe.**
- Minimising transport distances and enhancing service life of the layers are primary factors to reduce carbon footprint (increase environmental performance)
- **Transport distances should always be limited to 100 Km**
- Only in case of long service life the amount of RA plays a significant role

In the deliverables, soon…

AllBack2Pave

- **Comparison with other freely available EU-based LCA tools:**
  - **Full LCA with ECORCE M.** Similar results with asPECT and Water footprinting issues associated with reclaimed asphalt
  - **LCA with Carbon Road Map (CEREAL project). Results under review**
- LCCA of the case studies by using FHWA RealCost
- **Sustainability rating** by adapting GreenPave and BE^{2}ST to the EU environment and using ECORCE M (freely available tool) and RealCost
- **Recommendations for a needed CEDR sustainability rating system**

Questions?

http://allback2pave.fehrl.org/

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