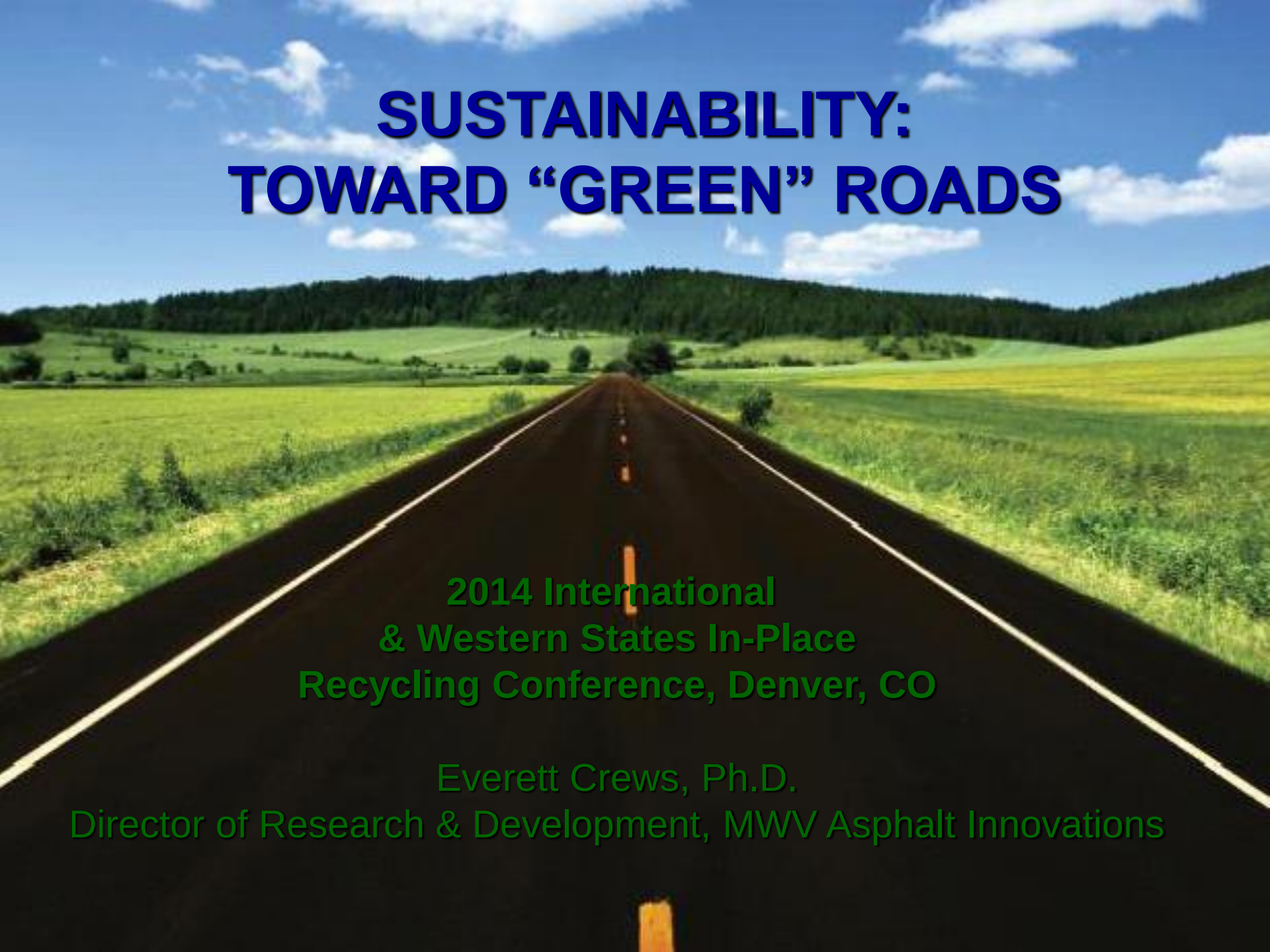


SUSTAINABILITY: TOWARD "GREEN" ROADS

2014 International
& Western States In-Place
Recycling Conference, Denver, CO

Everett Crews, Ph.D.
Director of Research & Development, MWV Asphalt Innovations

TOPICS OF TODAY'S PRESENTATION

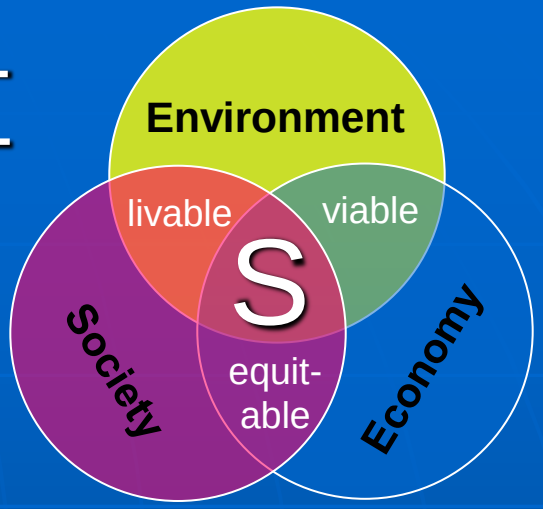
- Sustainability definition
- What it means to be "sustainable" road
- Drivers of sustainable roads initiatives
- Sustainable pavement programs worldwide
  - DuboCalc from Holland
- Focus on green recycling technologies
  - Recycling HIR, CIR, FDR
- Long-term pavement performance studies
- Comparative LCA studies
- Conclusions

SUSTAINABILITY

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (1)

(1) Brutland Report: "Our Common Future," 1987, UN World Commission on Environment & Development.

SUSTAINABLE DEVELOPMENT



Economic (GDP) Growth

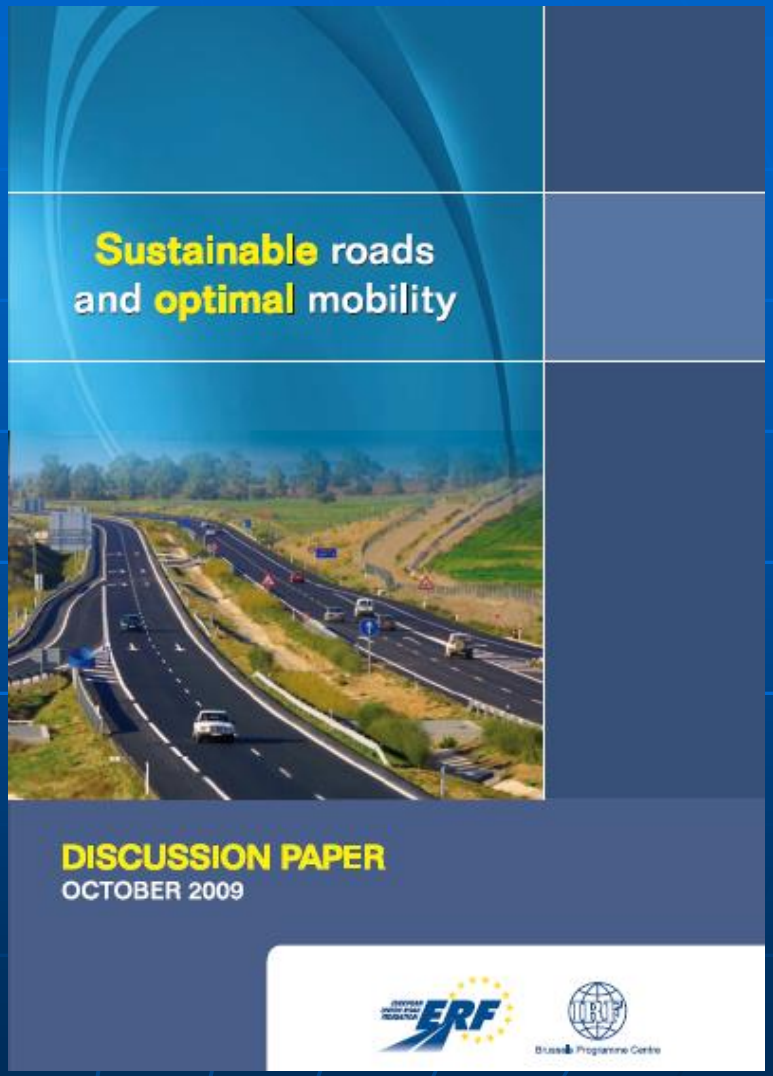
Neutral or positive Environmental Impact

Use of land (natural resources) & labor (manufacturing) to meet current demand levels for goods & services

While conserving, reusing, & renewing to prevent irreparable resource depletion/damage & / or waste accumulation

SUSTAINABLE ROADS: 2009

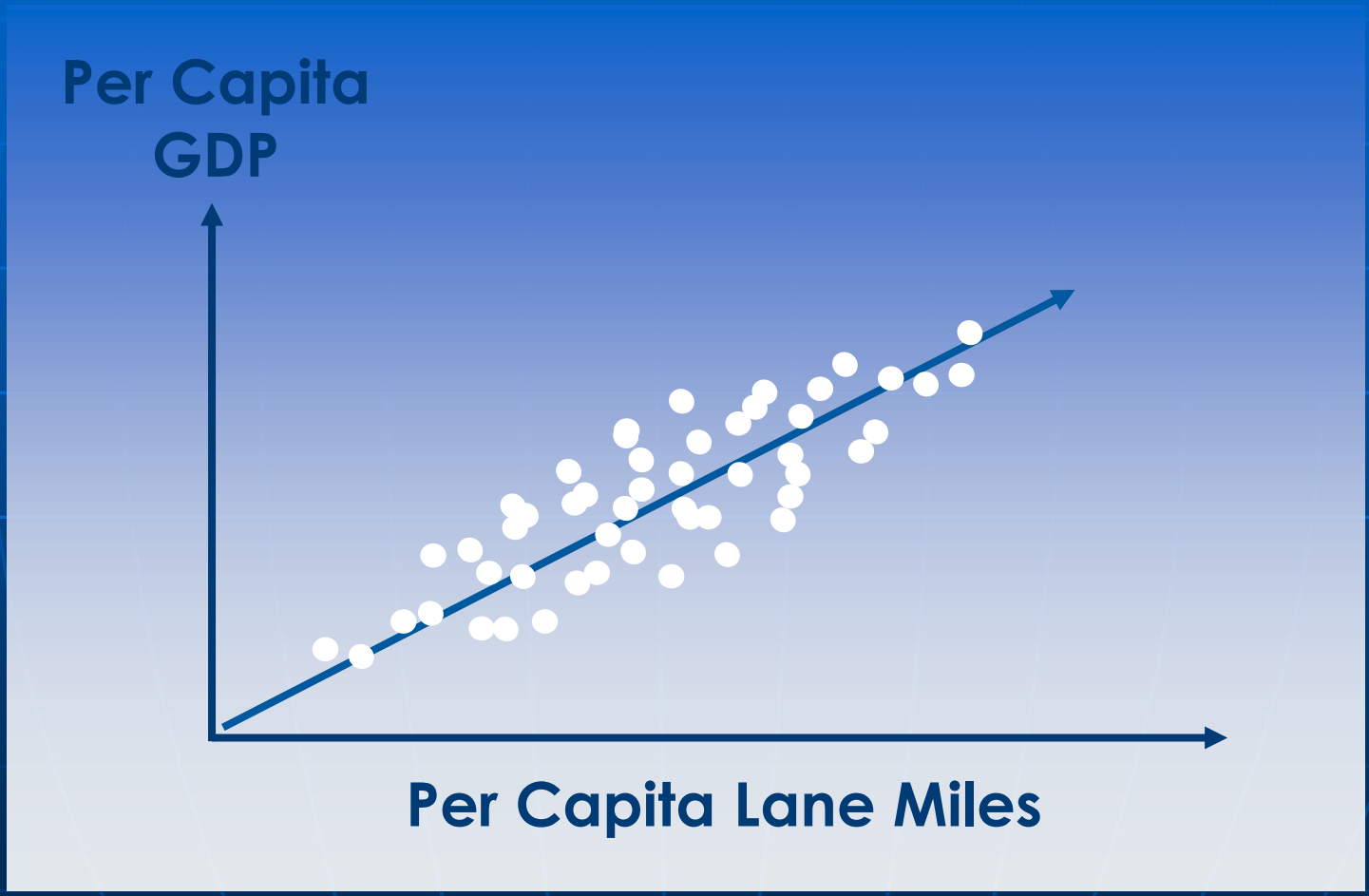
Roads that are "effectively & efficiently planned, designed, built, operated, upgraded, & preserved by means of integrated policies respecting the environment & providing the expected socio-economic services with optimal mobility & safety" (2) ensure sustainable economic growth.



(2) ERF & IRF BPC: "Sustainable Roads and Optimal Mobility," October 2009.

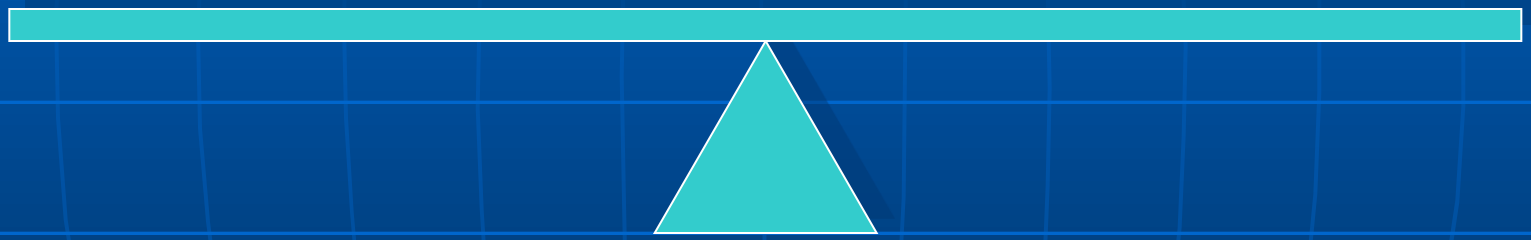
WHY ASPHALT ROAD SUSTAINABILITY?

It is well-established that per-capita GDP growth is directly proportional to the length of the highway network.



SUSTAINABLE ROADS: TODAY

"ASPHALT PAVEMENT DURABILITY" = SUSTAINABILITY AND ENVIRONMENTAL LIFE CYCLE



(2) ERF & IRF BPC: "Sustainable Roads and Optimal Mobility," October 2009.

SUSTAINABLE ROADS: 2014 IN THE EU

"ASPHALT PAVEMENT DURABILITY"

=

SUSTAINABILITY AND ENVIRONMENTAL LIFE CYCLE

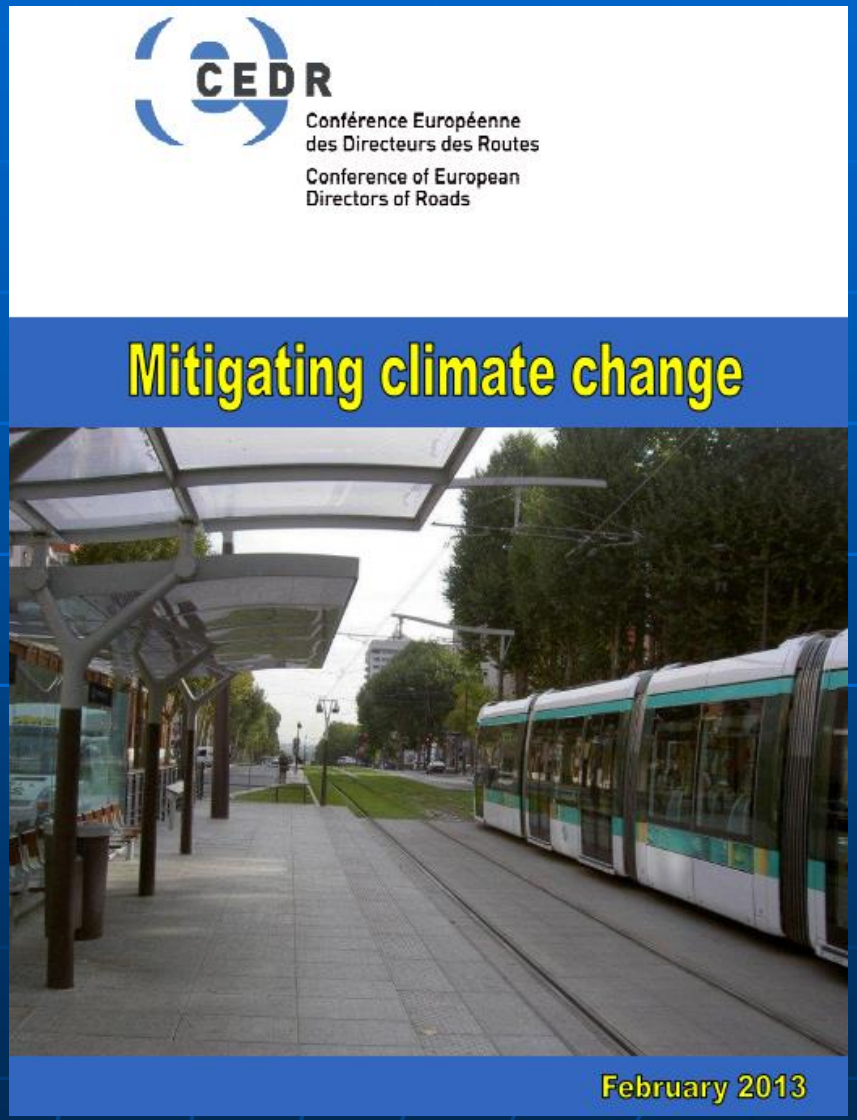
Pavement service life and maintenance treatments are influenced by durability

SUSTAINABLE ROADS: 2014 IN THE EU

"…in a post fossil-fuel world…"

"…multiple recycling while maintaining long-term eco-stability…"

"…mitigating climate change…"



INCENTIVIZING GREEN ROADS

WRAP

Highways Agency Carbon Calculator Tool

WLCO2T

DuboCalc

JouleSAVE

CO_2 Performance Ladder

CO2NSTRUCT

PaLATE

asPECT

ROAD-RES

AggRegain

Green Roads

LCI Model

AllBack2Pave 100% Recycling

GHG Calculator for Infrastructure

SEVE

GreenDot

AMW

Ecologiciel

INCENTIVIZING GREEN ROADS: DuboCalc

Ministry of Transportation Netherlands

1. *The DuboCalc software*
2. *The Library: a reference database with basic information*
3. *The project document (or project data)*

Instructions for use of DuboCalc can be found at
https://www.youtube.com/watch?v=LJY9QzxlW2w

INCENTIVIZING GREEN ROADS: DuboCalc

- Calculate the environmental impact of material and energy use
- Judge the sustainability of a design relatively quickly and easily
- Achieve significant environmental results
- Based on the methodology of the Life-cycle Analysis (LCA)
- Takes into account all the relevant environmental effects during the entire course of a project
- Expresses the effects of the project on the environment
- Environmental effect categories
- These effects are then translated into shadow prices
- This result is expressed as the value in Euros of the ECI

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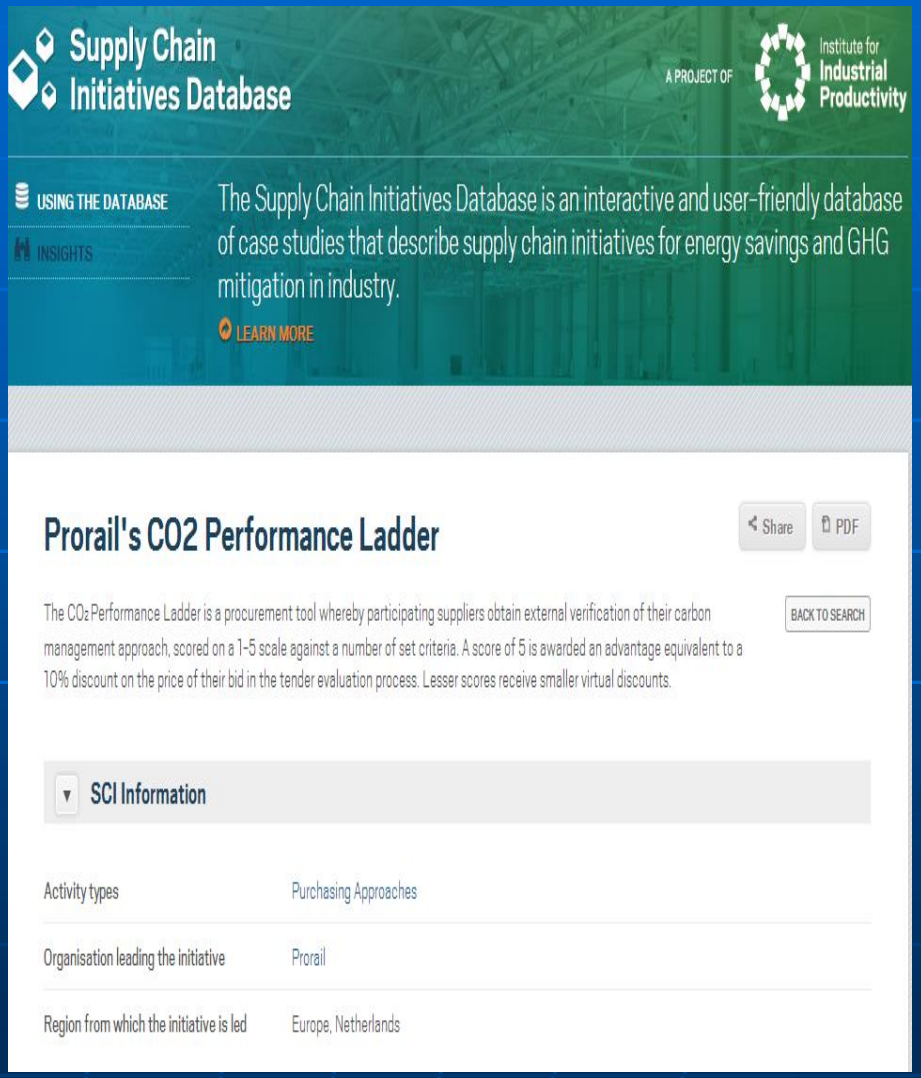
INCENTIVIZING: CO_2 Peformance Ladder

Vendors qualify for five levels of demonstrable CO2 management capabilities. With each level the owner (began with the rail agency in Holland) can offer **discounts off the tender bid.**

Level 5	10%
Level 4	7%
Level 3	4%
Level 2	2%
Level 1	1%



INCENTIVIZING: CO_2 Emissions Calculators

United States Environmental Protection Agency

European Environment Agency

Carbon footprint asphalt:

60 g CO_2 equiv/kg

Excerpted from J. van de Zwan, “How to Diminish Carbon Footprint of Roads,” E&E 2012, Istanbul, Turkey

INCENTIVIZING: CO_2 Emissions Calculators

United States Environmental Protection Agency

European Environment Agency

Carbon footprint asphalt:

60 g CO_2 equiv/kg

Carbon footprint orange juice:

1600 g CO_2 equiv/kg

Carbon footprint cheese burger:

6000 g CO_2 equiv/kg

Excerpted from J. van de Zwan, "How to Diminish Carbon Footprint of Roads," E&E 2012, Istanbul, Turkey

INCENTIVIZING: CO_2 Emissions Calculators

United States Environmental Protection Agency

European Environment Agency

Carbon footprint
milk:

2500 g CO_2 equiv/kg (17.6 lb CO_2 equiv/gallon)

INCENTIVIZING: asPECT in the UK

4 components of asPECT

- Protocol – a defined set of “rules” for footprinting asphalt products and applications
- Guidance – explains the decision making process behind the Protocol and provides worked examples
- Software – faciliates the calculation for those that choose to use it (calculations can alternatively be embedded into other company systems)
- Software User Guide

www.sustainabilityofhighways.gov.uk

INCENTIVIZING GREEN: AllBack2Pave

Sponsor: Confernence of EU Directors of Roads (CEDR)
Funding: $620,000
Goals: evaluate feasibility of moving to **100% recycled roads**

Currently relying on WMA technologies

INCENTIVIZING GREEN: CoRePaSol

Advanced **Co**ld **Re**cycled Bitumen Stabilized **Pa**vement **Sol**utions

Sponsor: Confernence of EU Directors of Roads (CEDR)
Funding: $480,000
Goals: evaluate feasibility of moving to 100% recycled base and binder layers

Tasks:
- establish new mix evaluation procedures and pavement design protocol
- establish long-term **ecostability**

INCENTIVIZING GREEN ROADS: USA

Greenroads 501(c)(3)

- Project Requirements
  - PR-1 Environmental Review Process
  - PR-2 Lifecycle Cost Analysis
  - PR-3 Lifecycle Inventory
  - PR-4 Quality Control Plan
  - PR-5 Noise Mitigation Plan
  - PR-6 Waste Management Plan
  - PR-7 Pollution Prevention Plan
  - PR-8 Low Impact Development
  - PR-9 Pavement Management System
  - PR-10 Site Maintenance Plan
  - PR-11 Educational Outreach
- Environment & Water
- Access & Equity
- Construction Activities
- Materials & Resources
- Pavement Technologies
- Custom Credit

INCENTIVIZING GREEN ROADS

INCENTIVIZING GREEN ROADS: FHWA

INCENTIVIZING GREEN ROADS: INVEST

Project Development by Criteria Scorecard	Paving	Urban Basic	Urban Extended	Rural Basic	Rural Extended	Custon Core Criteria[1]
PD-17 Energy Efficiency		√	√	√	√	√
PD-18 Site Vegetation		√	√	√	√	√
PD-19 Reduce and Reuse Materials	√	√	√	√	√	√
PD-20 Recycle Materials	√	√	√	√	√	√
PD-21 Earthwork Balance			√		√	
PD-22 Long Life Pavement Design	√	√	√	√	√	√
PD-23 Reduced Energy and Emissions in Pavement Materials	√	√	√	√	√	√
PD-24 Contractor Warranty	√	√	√	√	√	√
PD-25 Construction Environmental Training		√	√	√	√	√
PD-26 Construction Equipment Emission Reduction	√	√	√	√	√	√
PD-27 Construction Noise Mitigation		√	√			
PD-28 Construction Quality Control Plan	√	√	√	√	√	√
PD-29 Construction Waste Management	√	√	√	√	√	√
Total Number of Criteria in Scorecard	12	24	29	21	25	19

1 – Indicates the core criteria that must be included in the custom scorecard. The user may choose as many additional criteria as desired.

INCENTIVIZING GREEN ROADS: INVEST

INVEST Implementation Sites

INVEST
ECONOMIC • SOCIAL • ENVIRONMENTAL

By the Numbers

55 INVEST implementation projects
In 25 states and DC
By 29 agencies, including:
- 10 state DOTs
- 13 MPOs
- Federal Lands Highway Divisions (all 3 divisions)
- 4 other transportation agencies

State DOT
MPO
Federal Lands Highway
Other

U.S. Department of Transportation
Federal Highway Administration

INCENTIVIZING GREEN ROADS: INVEST

TABLE 1: POINTS FOR AVERAGE RECYCLED CONTENT (PERCENT BY WEIGHT OR VOLUME OF MATERIALS)

	Points Earned				
Recycling Method Used	**1**	**2**	**3**	**4**	**5**
Percent average recycled material (ARC) required for recycling in pavements	10%	20%	30%	40%	50% or more
Percent average recycled material (ARC) required for granular base course or embankments	20%	30%	40%	50%	60% or more

2-6 points. In-Place Pavement Recycling

TABLE 2: POINTS AWARDED FOR IN PLACE RECYCLING

	Points Awarded by Method of Recycling		
Percentage Pavement Area Recycled	**HIR**	**CIR**	**FDR**
50–74%	2	3	4
75–99%	3	4	5
100%	4	5	6

SUSTAINABILITY/DURABILITY STUDIES

Cold Insitu Recycling Evaluation

A Report of Research by

R. Gordon McKeen, P. E.
Director, Materials Research Center
Alliance for Transportation Research
1001 University Boulevard SE, Suite 103
Albuquerque, New Mexico 87106-4342

Under Contract for the

New Mexico State Highway and Transportation Department
Research Bureau
P. O. Box 1149
Santa Fe, New Mexico 87504-1149

Over 130 CIPR projects studied.

Service lives exceeded the 10-year design life.

Compared to mill and overlay, the CIPR projects saved

$12,109 / lane-mile

SUSTAINABILITY/DURABILITY STUDIES

COLD IN-PLACE RECYCLING (CIR) TECHNIQUE IN NEVADA: FIELD PERFORMANCE EVALUATION FOR A DECADE OF IN-SERVICE PERIOD

By

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SUSTAINABILITY/DURABILITY STUDIES

COLD IN-
PERFORM

By

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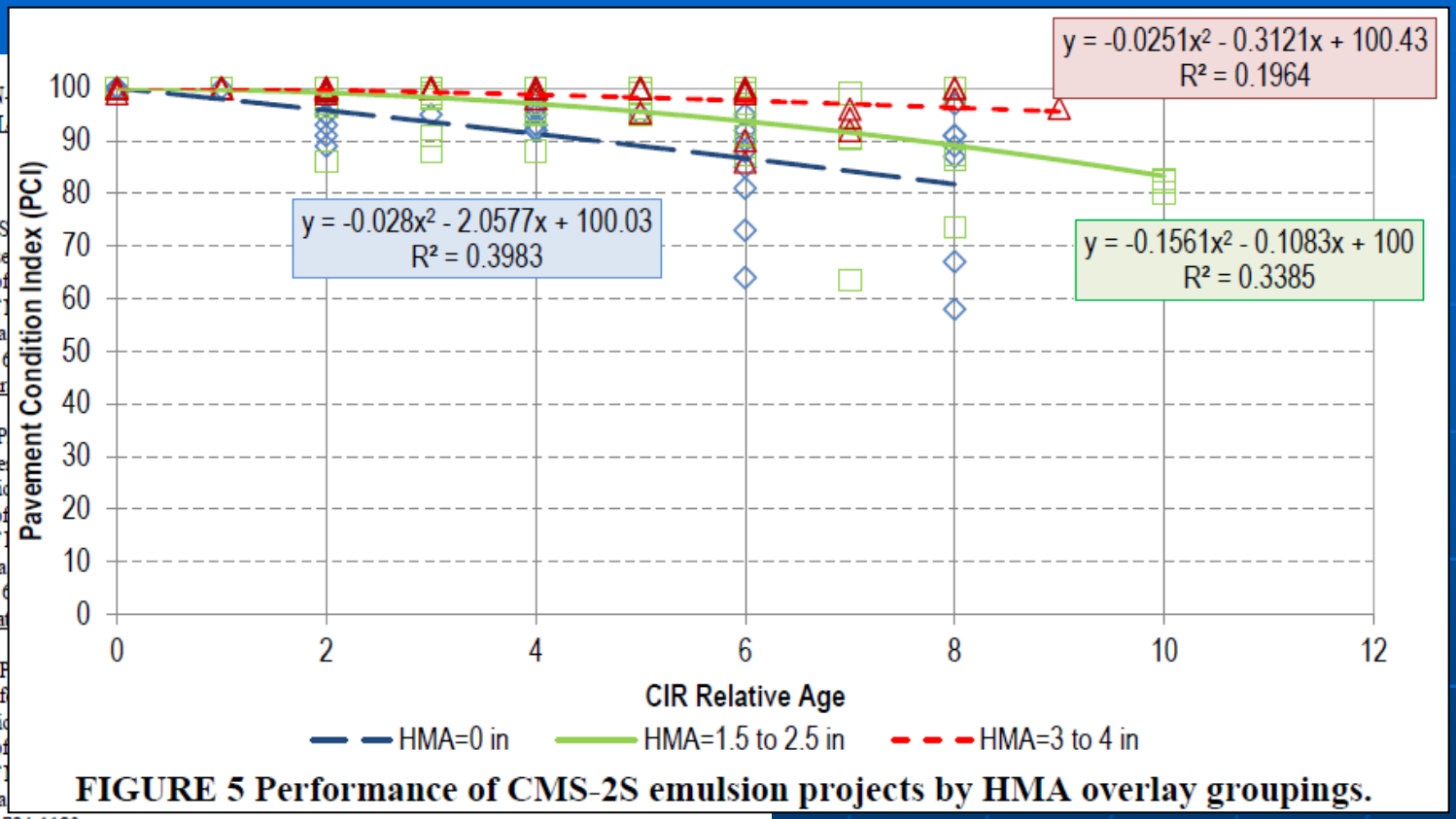

FIGURE 5 Performance of CMS-2S emulsion projects by HMA overlay groupings.

Service life extensions projected to 20 years before rehab required.

COLD RECYCLING ECO-STABILITY

Two Life Cycle Assessment studies [5a & 5b] have been published recently, showing the relative environmental impact (fuel consumption most notably) of different asphalt application (paving) technologies.

Energy consumption (MJ/t)

Product	Binders	Aggregates	Manufacture	Transport	Laying	Total (MJ/t)
Bituminous concrete	279	38	275	79	9	**680**
Road base asphalt concrete	196	36	275	75	9	**591**
High modulus asphalt concrete	284	38	289	79	9	**699**
Warm mix asphalt concrete	294	38	234	80	9	**654**
Emulsion bound aggregate	227	37	14	81	6	**365**
Cold mix asphalt	314	36	14	86	6	**457**
Road base asphalt concrete with 20% RAP	157	33	275	64	9	**538**
Road base asphalt concrete with 30% RAP	137	30	275	58	9	**510**
Road base asphalt concrete with 50% RAP	98	25	275	47	9	**454**
Emulsion in-situ recycling	105	4	-	15	15	**139**

(5a) Chappat, M. & Bilal, J. “Environmental Roads of the Future,” 2003.
(5b) Epps, J. & Robinette, C. 2010 TRB 10-2679.

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80% Reduction

(5a) Chappat, M. & Bilal, J. “Environmental Roads of the Future,” 2003.
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CONCLUSIONS

Sustainable recycling technologies are proven across the globe to extend pavement service life in an economical and eco-stable manner.

- Long-term pavement studies bear this out.
- Eco-analysis and LCA prove the eco-stability of recycling.

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- CO_2 Performance Ladder are seminal developments.

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In Europe, owners are providing monetary incentives to achieve sustainability goals of durability and eco-stability.

- DuboCalc and
- CO_2 Performance Ladder are seminal developments.

Trends toward greater implementation of sustainability programs are clear. Given demonstrable pavement durability & long-term performance data, we must ask ourselves what does our industry need to do to expand sustainable pavement construction technologies like recycling?

GREEN RECYCLING TECHNOLOGIES ARE MARKET-READY.

THANK YOU.